Diseases of the Ear

Thomas Barr, M.D.

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MANUAL

OF

DISEASES OF THE EAR

INCLUDING THOSE OF THE NOSE AND THROAT IN RELATION TO THE EAR

FOR THE USE OF

STUDENTS AND PRACTITIONERS OF MEDICINE

BY

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Printed at the University Press by
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Dedicated to

SIR JOSEPH LISTER, BART., LL.D., D.C.L., *P.*R.S.,

AS A TOKEN OF ADMIRATION AND GRATITUDE,

BY ONE OF HIS GLASGOW PUPILS.

PREFACE.

In issuing a second edition of this Manual an endeavour has been made, as in the former edition, to present the main facts of aural surgery in such a form as to meet the wants of medical students and practitioners.

In style and appearance the present volume differs considerably from the previous edition. The size of the page has been increased, and the general type is larger, with, occasionally, the introduction of smaller type in the case of less important matter, while bold black type is employed for paragraph headings. There are three additional chapters, and the number of illustrations has been doubled; on the other hand, the pages, being larger, are fewer in number. Of the additional illustrations, thirty-four are from process blocks, which are reproductions of photographs, depicting more especially methods of examination and treatment. A number of woodcuts have been kindly lent by Politzer, E. Cresswell Baber, and others, which are duly acknowledged. The whole work has been carefully revised, and, to a considerable extent, re-written. It is to be hoped that the result is a work neither too bulky for the student nor too meagre for the requirements of the practitioner.

It is generally admitted that the medical student should be called upon to devote some of his time to practical instruction in diseases of the ear, although there is not the same unanimity regarding compulsory attendance upon a systematic course of lectures. The desire has been to place in the hands of the student, engaged in practical aural work, a book which might take the place of a systematic course, if such be not available or desirable. Long experience in

teaching this subject has suggested the adaptations suitable for this end, one of which has been the introduction of a chapter on the Symptomatology of Diseases of the Ear.

In the chapters on Purulent Disease of the Ear and its Consequences, an effort has been made to keep up with the rapid strides taken within recent years. In this connection operations on the mastoid process and tympanic attic have been described more fully, as befits the very important advances in this field of work. An additional chapter on the Vascular and Intra-cranial Complications of Purulent Disease of the Ear has been found necessary in order to discuss, with sufficient fulness, operations on the intra-cranial cavity, the most important development in treatment which has taken place in connection with this branch of surgery since the issue of the first edition.

Ménière's disease and auditory vertigo have also come in for a larger share of attention, on account of their important bearing upon ordinary medical practice.

Two chapters, instead of one as in the first edition, are devoted to the nose and throat in relation to disease of the ear. The additional chapter is taken up with the *treatment* of these regions, and should be read in connection with the treatment of the various forms of middle ear disease. That in these directions many affections of the middle ear are more efficiently treated than by purely aural methods is now generally recognized. It has again been thought advisable to gather together in a list of Formulæ at the end the remedies recommended in the course of the work. There is reason to believe that this was regarded as a convenience to students and young practitioners. These Formulæ have been kindly revised by Mr. John M'Millan, pharmaceutical chemist of this city.

The general index is the work of Dr. J. Galbraith Connal, whose valuable help has been much appreciated. The general index is followed by an index of the authors referred to in the text, appended to which is a small bibliography, including the more important works and papers by these authors. This bibliography may be regarded by some as too limited. It did not seem, however, compatible with the purpose of the work to give a complete *resumé* of the literature of the subject. Thanks are due to Dr. Arthur J. Hutchison for

his assistance in the preparation of the index of authors and the bibliography.

In addition to the gentlemen already mentioned, I have to acknowledge the valuable suggestions and practical help so cheerfully tendered by Dr. C. Fred. Pollock. To Dr. William Ernest F. Thomson and Dr. A. W. Russell I am also much indebted for the revision of proofs while going through the press.

The new drawings have been executed by Mr. James Gilmour, who also provided the process blocks.

THOMAS BARR.

13 Woodside Place,
Glasgow, *October*, 1896.

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MANUAL OF

DISEASES OF THE EAR.

INTRODUCTORY NOTE.

MAIN ANATOMICAL AND PHYSIOLOGICAL DIVISIONS.

In the organ of hearing the physiologist recognizes—1st, the peripheral part, for the conduction of sound; and 2nd, the central part, more immediately connected with the perception of sound.

The part for the conduction of sound is divided by the anatomist into the external and the middle ear. The external ear is subdivided into the auricle and the external auditory canal; the middle ear is subdivided into the tympanum, the Eustachian tube, and the mastoid cells.

The part for the perception of sound is called the internal ear. This includes the labyrinth and the auditory nerve; the labyrinth being divided into the vestibule, the semicircular canals, and the cochlea. These contain the labyrinthine fluid and certain membranous structures, which support the terminal ramifications of the auditory nerve.

The external is separated from the middle ear by the tympanic membrane, while the internal ear is separated from the middle ear by the membrane of the fenestra ovalis and the membrane of the fenestra rotunda.

A short anatomical and physiological account will be given in connection with each of the divisions of the ear by way of introduction to the description of their diseases. It is not, however,

intended to treat the anatomical and physiological aspects of the subject exhaustively, but rather to draw attention to those points which have special bearings upon injuries and diseased processes. This plan, it is thought, will better serve the practical scope of the work than a complete anatomical and physiological description of the organ introduced as a separate section.

In order to avoid undue increase in the size of the volume, the anatomical and physiological descriptions are printed in smaller type.

CHAPTER I.

THE EXAMINATION OF THE EAR.

I. EXAMINATION WITH THE UNAIDED SENSES.

As the chief and most important parts of the organ of hearing lie concealed from view in the interior of the temporal bone, we have, in the examination of these deeply seated structures, to employ certain instrumental aids. While these are essential to the due investigation of the ear, we must not neglect the examination of the outer or superficial parts with the unaided senses, for in this way we may derive important information.

Auricle. The great varieties in the size, shape, and mode of attachment of the auricle to the side of the head are familiar to all, and are chiefly of interest from an aesthetic point of view. Many abnormal conditions are found, but some of these are of more interest to the general surgeon than to the aural specialist. Malformations of excess (supernumerary auricles) and of defect occasionally come under our notice. Tumours of various kinds more frequently present themselves, and one of the most interesting of these is that termed *hæmatoma auris* or the sanguineous tumour of the insane. Eczematous conditions are often seen on the auricle, either with crusts, scales, or hacks in the concavities, or with great enlargement and thickening. All such conditions will be sufficiently recognized by simple inspection or palpation.

External Auditory Canal. By pulling the auricle backwards and the tragus forwards we may, with good light, in this way see the greater part of the external auditory canal and even of the tympanic membrane. Before introducing a speculum it is wise

to inspect the orifice of the ear, as we may find conditions which forbid the introduction of a speculum. One of the most common objects found here is a plug of cotton wool, which must not be despised as a source of information, for, by inspecting it, we can often find the evidence of a discharge from the deep part of the ear, while from the smell, we may determine if the discharge is recent or of long duration. We may, in other cases, find purulent or muco-purulent secretion, granulation tissue, or even polypi (Fig. 1) protruding from the external orifice; and these all point undoubtedly to a purulent affection of the deep parts. Such conditions as exostosis, eczematous inflammation, thickening of the walls of the canal, and furunculi, may also be discovered by simple inspection, and the existence of these would necessitate great caution in introducing a speculum lest pain and injury be caused.

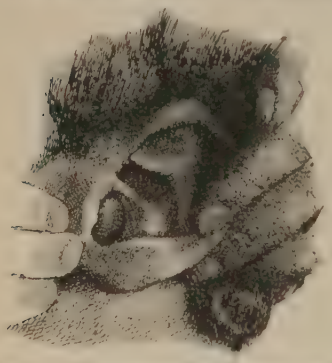

FIG. 1.—Polypus protruding from external meatus.

Mastoid Region. The mastoid or squamo-mastoid region yields by this mode of examination much valuable information, especially in purulent diseases of the middle ear. A large fluctuating swelling, with displacement outwards of the auricle, giving a very characteristic appearance, denotes mastoid or squamo-mastoid periostitis with abscess. A general bulging or fulness of the bone, painful on pressure, though perhaps presenting no inflammatory discoloration, would mean, especially if a discharge from the ear existed, a purulent collection in the mastoid cells. An open sinus, with granulation tissue sprouting from it, would denote caries or necrosis of the mastoid. A deep tunnel leading to the antrum might be the result of operative treatment, while a depressed bony cicatrix would mark the seat of an old sinus, or of an operation cavity.

FIG. 2.—Facial aspect in deafness associated with post-nasal growths.

Glandular Structures. The glandular structures in the vicinity of the ear should receive attention by inspection, but especially by palpation, for, with purulent mischief in the ear, these structures

are often inflamed or enlarged, or the seat of abscess or of tubercular disease. In this way the parotid in front, the glands over the mastoid behind, and those behind the angle of the jaw and in the neck are not infrequently involved. Where such conditions are found to exist, the interior of the ear should always be examined.

Facial Aspect. Lastly, the facial aspect of persons suffering from ear disease or deafness will often present peculiarities and attract our attention. An open mouth, with compressed nostrils and a dull stupid expression, is often associated with deafness in childhood (Fig. 2), while paralysis of one side of the face, or, though much more rarely, of both sides, may have its source in middle ear disease, especially the suppurative form.

II. EXAMINATION THROUGH THE EXTERNAL AUDITORY CANAL.

In most cases, in order to survey in all their detail the deep parts of the external auditory canal, the tympanic membrane and the interior of the tympanum, we require, first, to remove or turn aside any obstructions in the canal of the ear; second, to straighten the curve of the canal; and, third, to reflect light into the interior.

Removal of Obstructions in the Canal. The view of the deep parts of the ear is very frequently obstructed by hairs, particles of cerumen, epidermic scales, purulent secretion, etc. The aural speculum suffices to push aside the hairs. The cotton holder (Fig. 3) is the

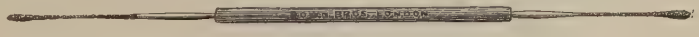

Fig. 3.—Cotton holder.

safest instrument to employ in removing other substances. It consists of a piece of iron or steel wire, both ends of which are wrought into the form of a fine screw, round which, before use, a piece of cotton is firmly wound into a cylindrical shape. If syringing is required, as for instance in removing purulent secretion, the interior of the ear must afterwards be carefully dried with cotton, applied by means of the cotton holder. Metallic instruments, such as forceps or a probe, may be required to remove scales or particles of cerumen; but they must be used with caution, and only when the inside of the ear is properly illuminated, so that the eye may guide the hand.

Aural Specula. The curve of the canal may be straightened more or less by pulling the auricle upwards and backwards, and by the introduction of an aural speculum. The aural speculum is a funnel-

shaped tube, about an inch and a half in length, composed of either silver (Fig. 4) or vulcanite (Fig. 5). The metallic ones are the most suitable, especially those known as Gruber's, which have an oval lumen at the narrower or inner end. Four sizes are necessary in order to fit the various widths of the external canal of the ear in different persons and at different ages. Grunfeld has, by connecting an oval mirror to the outer opening of a speculum with a hinged joint, constructed a demonstration speculum, so that an observer looking at the mirror may see the reversed image of the tympanic membrane. Kramer's bivalve aural speculum possesses no advantages over the simple tubular one, while it is apt to cause

FIG. 4.—Gruber's speculum.

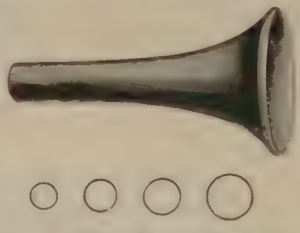

FIG. 5.—Politzer's vulcanite speculum.

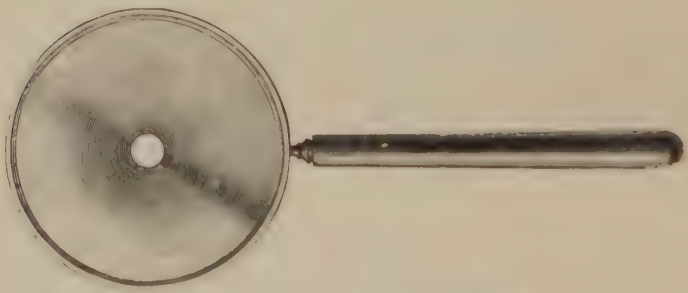

FIG. 6.—Concave perforated mirror with handle.

pain and injury to the ear. For the same reason long specula are to be avoided unless in practised hands.

Reflecting Mirror. The best method of illuminating the interior of the ear is by reflecting light from a concave mirror. This should have a diameter of about two and a half inches, be perforated by a small hole in the centre, and have a focal distance of from three to five inches. It is used either with a handle (Fig. 6) screwed on to the metallic back, or, if the right hand requires to be free, as in operating, it is attached to a head band by means of a ball and socket joint, and is thus supported in front of the eye of the operator. For persons with faulty refraction a proper lens may be fitted behind the perforation in the mirror, or suitable spectacles

should be worn. A flat mirror is desirable when we wish to employ the direct rays of the sun.

Source of Light. Bright diffuse daylight, especially the light reflected from white clouds or a white wall, affords the best illumination. It is often necessary, however, to employ artificial light, which, it is to be noticed, imparts a reddish-yellow tint to the parts. Either lamp-light or gas-light will serve the purpose, and, in the latter case, an Argand burner, or preferably an incandescent gas burner, having a long glass tube covering the light, is most suitable. A portable oil lamp is useful for the bedside. The oxyhydrogen limelight may be required for delicate operative work. The Photophore or incandescent electric lamp, introduced by Trouvé, fixed

Fig. 7.—Position of fingers in using the speculum.

on the forehead and supplied with a storage battery, is sometimes employed, but is less convenient, and no more efficient than gas. An incandescent electric lamp, used along with a reflecting mirror, affords good illumination.

Introduction of the Speculum. Before attempting to introduce the speculum, it is well to reflect light into the external orifice of the ear, so as to get an idea of the width and condition of the canal, as a guide in selecting the size of the speculum required. This precaution is also necessary in case the canal should happen to be acutely inflamed, when the attempt to introduce a speculum

would be attended by intense pain. In introducing the speculum (which should be warmed, and as wide as can be accommodated in the canal), the auricle is held upwards and backwards with the left hand, while the speculum, held at its outer edge between the thumb and first two fingers of the right hand, is passed by a sliding and turning movement into the canal for about half an inch, or as far as it will go without causing pain. In order to avoid the angular projection at the antero-inferior wall of the canal, the speculum should be kept well in contact with the upper straight wall.

Mode of using the Mirror and Speculum. The examiner now takes the mirror by its handle in his right hand, and places the back of the reflector in contact with his right eyebrow, so that the hole in the mirror is opposite the pupil. His head is brought sufficiently near to the patient's ear (four or five inches, according to the focal distance), and the reflecting surface of the mirror is moved in such a way that the reflected light is projected into the speculum. The speculum is at the same time held in proper position between the thumb and index finger of the left hand, while the auricle is held upwards and backwards, with the index finger in the concha and the middle finger behind the auricle (Fig. 7). The speculum is then moved about in different directions, so as to pass in review all the parts of the tympanic membrane. If the speculum is not supported in this way, it will very likely fall partially out of the opening of the ear, and, instead of having the membrane in view, only some part of the walls of the canal will be seen by the examiner. As the use of the mirror with the forehead band is necessary in manipulating the ear, so as to set free the right hand, it is important that the student should practise this method as soon as possible (Fig. 8).

FIG. 8.—Examination of the ear with forehead mirror and speculum.

Brunton's Speculum. This instrument consists of a metallic tube furnished with an eye-piece at the one end, and an ear speculum at the other end. The eye-piece has a lens of some

magnifying power. Light, natural or artificial, is admitted at the side through a wide funnel-shaped tube of polished silver, and falls upon a perforated mirror, which is set at an angle of 45 degrees in the interior of the tube. The light is reflected by this mirror through the speculum into the ear, from which it passes back through the perforated mirror and the convex lens to the eye of the observer. This instrument is inferior in simplicity, convenience, and efficiency to the speculum and mirror just described. There is greater difficulty in reflecting the light into the ear, and there is more risk of hurting the patient, while its use is limited to diagnostic purposes. In practised hands, owing to its magnifying

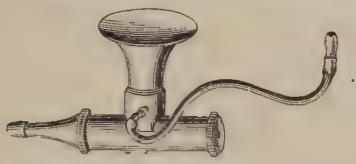

FIG. 9.—Brunton's speculum, with suction tube.

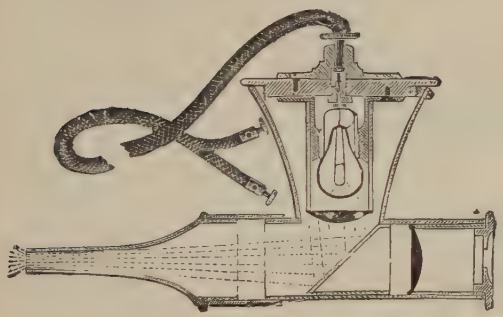

FIG. 10.—Brunton's speculum, with electric lamp.

FIG. 11.—Siegle's pneumatic speculum.

power, this speculum may be sometimes useful in revealing minute or obscure changes. By means of Voltolini's modification of it (Fig. 9), the column of air in the external auditory canal may be condensed and rarefied, as in the case of Siegle's speculum. A modification has also been constructed by K. Schall, in which the source of light is a small electric lamp placed in the funnel-shaped tube (Fig. 10).

Siegle's Pneumatic Speculum. This speculum (Fig. 11) is of great value in the diagnosis of certain morbid conditions of the middle ear. It consists of a vulcanite speculum screwed on to one end of a vulcanite cylinder, closed at the other end by a plate of glass placed obliquely, or, if we wish to magnify the parts, by a convex lens. The side of the cylinder has an aperture, over which a perforated peg is fixed. To this peg is affixed an india-rubber tube, furnished at its other end with a mouth-piece, or with an

india-rubber ball. The speculum is fitted air-tight into the external auditory canal, and, while we illuminate the interior by means of the mirror attached to the forehead, we alternately rarefy and condense the air in the canal either with the mouth, or by compressing and relaxing the ball. It is necessary to cover the end of the speculum with a short piece of india-rubber tubing, in order to make it fit the external auditory canal exactly. A force pump has been devised by Delstanche (Fig. 12) to regulate and intensify the traction. By the pneumatic speculum, we ascertain the degree of mobility of the tympanic membrane, and the presence of cicatrices or adhesions.

Conditions revealed by Speculum and Mirror. (1) We must note the condition of the *external canal*, such as its curvature and width, the colour of its lining, the injection of its vessels, and the quantity and character of the cerumen. We must note also if any of the following conditions exist:

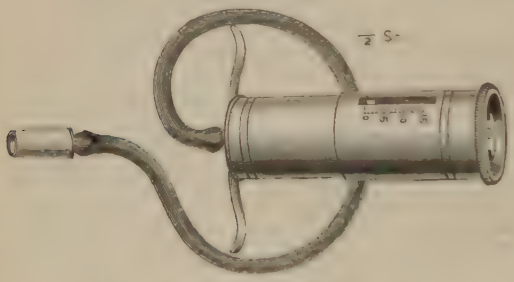

FIG. 12.—Delstanche's suction apparatus.

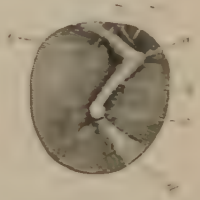

FIG. 13.—Outer aspect of right tympanic membrane—double the natural size; *a*, short process; *b*, middle of manubrium; *c*, umbo; *d*, cone of light; *e*, membrana flaccida; *f*, posterior fold; *g*, long process of incus shining through the membrane.

purulent or mucous secretion, sodden epidermis, polypi, hyperostosis or exostosis, inflammatory thickening or swelling of the cutaneous lining, furunculi, or necrosed bone. (2) We should inspect with great care the condition of the *tympanic membrane.*

Appearance of the Normal Tympanic Membrane. The tympanic membrane (Fig. 13), when viewed by reflected light, presents a beautifully polished appearance, is of a pearl-grey colour, and has a general concavity outwards. The most prominent object to be seen is the *short process of the malleus*, a small rounded white knob, near the upper border of the membrane, projecting towards the external auditory canal. From this a whitish ridge or stripe, sometimes having a tinge of yellow or red, is seen passing downwards, backwards, and slightly inwards to a point somewhat below the middle of the membrane, where it expands into a spatula-shaped extremity termed the *umbo.* This stripe or ridge is the *manubrium*, or handle of the malleus, shining through the outer and middle layers of the membrane. If the line of the manubrium were prolonged to the lower edge of the membrane, the latter would be divided into an anterior and a posterior part, of which the posterior would be the larger. Extending from the lower end of the manubrium downwards and forwards to the antero-inferior margin of the membrane,

there is seen a specially bright reflection called the *cone of light*, having usually a triangular shape, with the apex towards the umbo. From the short process of the malleus we also notice a distinct ridge, formed by a fold of the membrane passing backwards to the periphery,—this is the posterior fold. A smaller and less distinct fold, the anterior, is seen in front of the short process. The part of the membrane situated above the short process, and above these two folds, is known as the *membrana flaccida*. In many persons we see also the *long process of the incus* shining through the membrane as a whitish streak, parallel with, and slightly behind, the upper part of the manubrium. For the anatomical description of the external auditory canal, see Chapter VII.; and for that of the tympanic membrane, see Chapter VIII.

Abnormal Tympanic Membrane without Perforation. If the membrane is diseased, we should determine first if it is entire; if so, the following points require our attention:—

Are the colour, polish, and transparency of the membrane normal? Is there a general redness, or are the vessels individually injected, especially in the membrana flaccida and along the manubrium? Is the colour in whole or in part yellowish or yellowish green, indicating the presence of secretion in the tympanum? Are there opacities, local or general, or calcareous deposits? Is there a cicatrix—a dark, sharply defined, depressed part of the membrane—indicating a past perforation? What is the form and extent of the cone of light? Is the membrane, in whole or in part, bulged outwards from the effects of exudation in the tympanum or in the interstices of the membrane? Or, on the contrary, is the membrane depressed, sunken, with the manubrium drawn in and foreshortened, with increased prominence of the short process and anterior and posterior folds? Are the incus, stapes, and promontory more distinctly seen than in the normal condition, owing to a sunken or atrophied membrane? Is the manubrium clearly seen, and is it thinner and smaller than it ought to be? Are there small, shining prominences in the membrana flaccida, and is this area of the ordinary size?

Is there normal mobility of the membrane as tested by Siegle's speculum, or are there atrophied parts or cicatrices, or are there adhesions between the membrane and the inner wall of the tympanic cavity?

Abnormal Tympanic Membrane with Perforation. If a part of the membrane is destroyed, we must determine the size, shape, and situation of the perforation, as well as the condition of the mucous membrane of the exposed tympanum. Is the mucous membrane pale and dry—swollen, thickened, congested, and secreting—the seat of granulations or polypoid growths? Is any part of the incus or stapes exposed by the perforation? Does the part of the membrane which remains adhere to any part of the tympanic walls or contents, or is it congested, infiltrated, or thickened, or is it the seat of calcareous deposits? What is the condition of the manubrium? Is it shortened or even quite invisible, or is it complete but partially divested of its membranous attachment, or is it adherent to the inner wall of the tympanum?

III. EXAMINATION THROUGH THE EUSTACHIAN TUBE.

This consists in observing the effects produced when compressed air is forced into the pharyngeal mouth of the Eustachian tube,

termed inflation of the middle ear. We shall consider, first, the methods of inflating the middle ear: and, second, the information derived from these methods.

There are three methods of inflation usually practised.

(A) Catheterization of the middle ear.
(B) Politzer's method.
(C) Valsalva's method.

(A) *CATHETERIZATION OF THE MIDDLE EAR.*

A suitably formed tube—the ear catheter—is passed through the inferior meatus of the nose into the pharyngeal opening of the

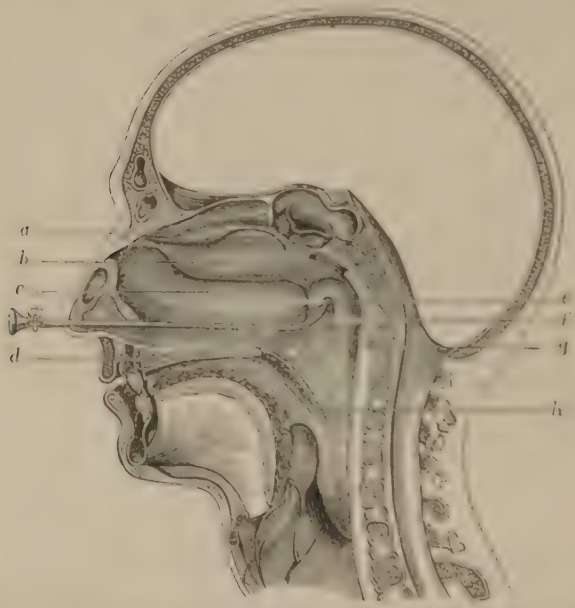

FIG. 14.—Vertical section of head, showing catheter introduced into the mouth of the Eustachian tube (after Politzer); *a*, superior spongy bone; *b*, middle spongy bone; *c*, inferior spongy bone; *d*, hard palate; *e*, posterior end of inferior spongy bone; *f*, mouth of Eustachian tube, with bulging above and behind; *g*, Rosenmüller's fossa; *h*, soft palate.

Eustachian tube (Fig. 14), and then a current of air is forced through the catheter.

FIG. 15.—Vulcanite Eustachian catheter.

Ear Catheter (Fig. 15). This is a tube, made of either silver or vulcanite, curved at one end. The outer end is widened into a funnel-shaped opening, which fits on to the mouth-piece of an

india-rubber bag, while the inner end is narrow for insertion into the mouth of the Eustachian tube. A catheter of medium size has a length of five and a half inches, and a free diameter at the outer end of a quarter of an inch, and at the inner end of one twelfth of an inch. The beak should measure an inch in length, and should form an angle of 135 degrees with the rest of the catheter. In order to suit the varieties in the capacity and form of the inferior meatus and of the naso-pharynx, it is necessary to have a number of catheters differing in thickness, and in the length and degree of curvature of the beak. The most efficient catheter is one which is pretty wide, and has a strongly curved beak. A ring is attached to that side of the outer end of the catheter which corresponds with the direction of the point of the beak, so that, when the catheter is introduced, the situation of the ring informs the operator of the position of the beak.

Vulcanite catheters possess several advantages over those made of silver. They are not injured by fluids injected through them; they are less unpleasant to the patient; and by their elasticity the operator can more easily evade obstructions which may exist in the nasal passages.

Precautions before using the Catheter. Before using a catheter it is well to inspect the nasal passages by means of a mirror and

FIG. 16.—Inspection of anterior nares.

speculum (Fig. 16), in order to ascertain if any obstruction exists to the passage of the catheter, and the nature of that obstruction. In sensitive patients the application to the mucous membrane of the nose of a 10 per cent. solution of cocaine on cotton wool, or by means of a spray, is useful. A current of air should also be forced through the catheter to test its permeability. Both patient and operator should be seated, the face of the former being well exposed to the light. As most patients tend to move the head

backwards, while the catheter is being introduced, the back of the head should rest against some firm support. The four fingers of the surgeon's left hand rest on the patient's forehead, while the thumb gently presses up the tip of the nose.

First Stage of Catheterization. The first stage of the operation consists in passing the instrument through the inferior meatus of the nose, till the point of the beak is felt to be in contact with the posterior wall of the naso-pharynx. The catheter is held like a pen between the thumb and first two fingers of the right hand, and the point of its beak is placed within the external orifice of the nose, so that the instrument forms an acute angle with the lower part of the face. The operator should then at once raise the catheter to the horizontal position, placing the point carefully in contact with the floor of the nasal passage, which, it is to be remembered, is under the level of the inferior edge of the nasal entrance. The instrument should now be pushed carefully, but not too slowly, along the inferior meatus, until its point touches the hard posterior wall of the naso-pharynx. When introduced properly, the outer part of the catheter forms a right angle with the face. If it has slipped into the middle meatus—the most common mishap of the beginner—it will form an obtuse angle with the upper part of the face, and while in this position pain is excited.

Second Stage of Catheterization. The second stage of the operation consists in moving the point of the catheter from the posterior wall of the pharynx to the mouth of the Eustachian tube. This may be done in several ways. (1) *Gruber's method* consists in withdrawing the catheter till the beak is felt to embrace the soft palate. The point is then turned outwards. The distance between the posterior wall of the pharynx and the edge of the soft palate presents great varieties during the movements of the palate, so that this method is uncertain. (2) *Politzer* turns the point of the catheter outwards into the fossa of Rosenmuller, and then, keeping the point in contact with the mucous membrane, he withdraws the catheter, until its point is felt to pass over the usually well marked rounded projection forming the posterior lip of the mouth of the tube. This method is generally the simplest and most certain. (3) *Löwenberg's* plan consists in turning the point of the catheter inwards towards the opposite side, and then withdrawing it until the beak hooks round the posterior edge of the nasal septum. The catheter is now rotated downwards and outwards, so as to describe a half circle, when the point is usually at the mouth of the tube. Both Politzer's and Löwenberg's methods possess the advantage of having well marked and fixed anatomical guides, namely, the cartilaginous

projection behind the mouth of the Eustachian tube, and the posterior edge of the nasal septum, respectively. These methods are therefore to be preferred to that of Gruber. When the point of the beak is at the mouth of the tube, the external end of the catheter should be gently pressed against the nasal septum, and the ring turned up towards the auricle of the same side. This forces the point well into the mouth of the Eustachian tube.

Difficulties in the First Stage. There is, in most cases, very little difficulty in this stage. In order to prevent the catheter slipping into the middle meatus, the instrument must be kept in the horizontal position, with the point of its beak in contact with the floor, while it is being passed. If an obstruction exists to the passage of the catheter it will usually be found that the free space between the outer and the inner wall of the nasal passage is encroached upon, or even obliterated, either by bulging of some part of the nasal septum to one side, or by an abnormally large and projecting inferior spongy bone, or by swelling of the whole extent of the nasal mucous membrane. Nasal polypi more rarely form obstructions to the introduction of the catheter. By a little manipulation the surgeon is generally able to overcome these difficulties. If the hindrance is produced by a large and prominent spongy bone, the point of the catheter should be turned outwards, so as to get it under the bone, where less resistance is met with. Success is sometimes achieved by directing the point upwards, or by insinuating the catheter in a spiral fashion. If these changes in the position of the catheter are not sufficient to overcome the difficulty, a thinner catheter, and one having a smaller curve, should be tried. If all of these expedients fail, the catheter may be introduced through the opposite nostril. In this case an instrument is used having a very long beak and a pretty strong curve. Such a catheter is passed in the way already described, and the point is then turned inwards and withdrawn, till the beak is felt to be in contact with the posterior edge of the septum, when the point will be near to, or in the mouth of, the Eustachian tube of the opposite side, that is, the side upon which we wish to operate.

Difficulties in the Second Stage. In regard to this stage, there is sometimes difficulty in turning the beak of the catheter. This may be due to the space between the posterior edge of the nasal septum and the mouth of the tube being unusually small, owing to peculiarity of formation. Or the free space of the upper pharyngeal cavity may be diminished by great swelling of the mucous membrane, or by the presence of post-nasal growths. We can overcome these difficulties by using a catheter having a short and slightly curved beak. Or spasmodic contractions of the pharyngeal muscles may

seriously hinder the turning of the catheter. The spasm generally passes off when the patient breathes deeply a few times through the nose. The contact of the catheter with the mucous membrane of the nose or pharynx sometimes excites coughing, sneezing, or retching, but it is sufficient simply to let go the catheter until these pass off. There is occasionally slight bleeding from the vascular membrane, with which the catheter is in contact, but rarely more than a stain of blood on the beak of the catheter is seen.

How the Catheter is retained in situ. When the catheter has been properly introduced, it is retained *in situ* most conveniently

Fig. 17.—Catheterization.

Fig. 18.—Catheter inflating bag.

by being held between the thumb and index finger of the left hand, while the hand is steadied by resting the other three fingers on the forehead and bridge of the nose (Fig. 17). The surgeon, who is accustomed to perform catheterization, is generally able to satisfy himself by touch alone that the catheter is properly introduced, but it is better to prove by actual inflation and auscultation that the point of the catheter is properly inserted into the mouth of the Eustachian tube.

Third Stage of Catheterization. The third stage of catheterization consists in forcing air through the catheter into the middle ear. The ear catheter may be looked upon as a tubular prolongation of the Eustachian tube, and as thus providing a channel by which gases, liquids, or solids may be introduced into the middle ear. A current of air is most frequently used; but warm water, warm medicated liquids, medicated vapours and gases, laminaria tents,

bougies, and electrodes are also employed. We shall at present confine ourselves to the consideration of the use of compressed air as a method of diagnosis.

Catheter Inflating Bag. In order to force air into the catheter, a pear-shaped india-rubber bag or balloon, of a size capable of containing eight or ten ounces of fluid, is required (Fig. 18). This bag is furnished with a tubular mouth-piece, made of horn or vulcanite, somewhat conical in shape, so as to fit accurately into the funnel-shaped opening of the catheter. While the catheter is being introduced, the air-bag may be conveniently held in the left arm-pit of the surgeon.

Mode of Inflation. The catheter having been introduced and being retained in position by the left hand, the air-bag is grasped by the right hand in such a way that the thumb and four fingers embrace or encircle the lateral parts of the bag. The mouth-piece of the bag is placed in the outer opening of the catheter (Fig. 17), and the bag is then firmly compressed between the four fingers and thumb, so as to force the air into the catheter. Before relaxing the hand, the mouth-piece of the bag should be withdrawn from the catheter, and then the bag allowed to fill with air. Three or four compressions of the bag are generally sufficient, although in cases of great obstruction to the passage of air through the Eustachian tube, six or eight may be required. The use of a compression pump is rarely, if ever, necessary. If the patient swallows during compression of the bag, the air usually passes in more freely, owing to the contraction of the *tensor palati* muscle. The surgeon must be careful not to press the bag too strongly or quickly, till he is convinced by the amount of resistance that the point of the catheter is really between the lips of the tube, and not pressing on the mucous membrane. He must also be careful during the compression of the bag not to push the catheter inwards, and thus violently force the point upon the mucous membrane.

Possibility of Emphysema. If, during compression of the air-bag, the point of the catheter is forced through the mucous membrane, or if it is pressed upon an ulcerated surface, the air may pass under the mucous membrane and produce emphysema of the neighbouring parts, such as the soft palate, uvula, cheek, or neck. While emphysema has occurred with the most experienced aural surgeons, there has been no instance of a fatal result, with the exception of two cases, in which a powerful air-pump was employed by an unskilled person. If air is forced into the catheter by compression of an air-bag with the foregoing precautions, emphysema will be an extremely rare accident and can never prove a serious complication.

Disinfection of the Catheter. After use, the catheter must be

thoroughly syringed out with a 5 per cent. solution of carbolic acid in water. The importance of this precaution has been demonstrated by several cases, in which secondary syphilis has been transmitted through the medium of the catheter. After its use in a syphilitic patient, the same catheter should not be again employed till it has been immersed in the carbolic solution for twenty-four hours, and then thoroughly cleaned inside as well as outside. In such cases, however, and indeed in all cases where patients require the frequent and long-continued application of the catheter, it is well, in order to avoid any possible risk, to reserve a catheter for each.

(B) *POLITZER'S METHOD OF INFLATING THE MIDDLE EAR.*

We pass now to the very important method of inflating the middle ear, named, after its discoverer, Politzer's method.

Description of Politzer's Method. Professor Adam Politzer, of Vienna, demonstrated in 1863 that the Eustachian tubes and the tympana can often be effectually inflated by a method tolerated even by the youngest children. The method (Fig. 19) consists in this:—After the patient has taken a small quantity of water into his mouth, the nasal piece of a tube connected with an air-bag is placed about one-third part of an inch into the nose close to the floor, the nasal passages being completely closed in front by compressing the nostrils firmly with the thumb and index finger of the left hand. The air-bag is then grasped by the right hand; the act of swallowing the water is performed by the patient at the command of the operator; and, at the same moment, the bag is forcibly compressed, and suddenly emptied into the closed nasal cavity. The closure of the nasal cavity posteriorly is effected in the act of swallowing by the elevation of the soft palate and its apposition to the posterior wall of the pharynx, while the sudden increase of density in the air contained in the shut nasal cavity, produced by emptying the air-bag, overcomes the resistance in the Eustachian tubes, and air passes freely into the tympana. In the act of swallowing, also, the contraction of the muscles of the Eustachian tube facilitates the passage of air into the tympanum.

FIG. 19.—Politzer's method of inflating the middle ear.

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Modifications of Politzer's Method. In very young children the act of swallowing is often unnecessary for the success of the inflation. This peculiarity is due to the fact that the Eustachian tube in early childhood is shorter, wider, and more dilatable than in adult years. If the child cries, the inflation is made more effectual. Lucæ, of Berlin, pointed out that the utterance of certain sounds, especially the sound of "ah," was attended by the apposition of the posterior edge of the soft palate to the posterior wall of the upper pharynx; and Gruber, of Vienna, found, as the result of experiments, that the pronunciation of the syllables, "hick," "hack," or "huck" (pronounced "hook"), with emphasis on the final letter, was still more effectual in closing the posterior nasal cavity. This modification of Gruber is a good substitute, in the case of children, for the swallowing of water. It is simpler, and takes less time than the original method of Politzer. In most cases, however, the swallowing of water seems to be more effectual, owing to the assistance gained by the contraction of the tensor palati in swallowing, than the phonation of "hook"; and the writer uses the latter in adults only when the former method is very unpleasant or ineffectual. If we desire a greater effect to be exercised upon one ear, we may close the opposite ear tightly with the finger, and cause the patient to incline his head well to the side on which the least effect of inflation is desired. Blowing out the cheeks during inflation, as recommended by Holt, is also a good substitute for the swallowing of water.

Instruments for Politzer's Method. The instruments required for Politzer's method are, an air-bag with suitable nose-piece,

Fig. 20.—Politzer's nasal piece and tube.

Fig. 21.—Soft nasal piece.

and an auscultation tube. The bag used may be the same as for catheterization. Several kinds of nasal pieces are employed. Politzer himself used one shaped like a catheter, and connected to the mouth-piece of the bag by means of a soft india-rubber tube, two or three inches in length (Fig. 20). The beak-shaped extremity of the hard nasal piece, which should be somewhat flattened, may be covered with soft india-rubber tubing, which

renders it less unpleasant, and less likely to hurt the nasal mucous membrane. A fresh piece of tubing should be affixed for each patient. A soft nasal piece (Fig. 21) made of thick india-rubber somewhat flattened at the side is perhaps less disagreeable than the thin nasal piece, and is therefore specially suited for children

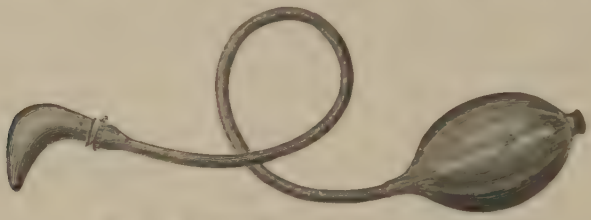

Fig. 22.—Gardiner Brown's inflating apparatus.

and sensitive persons: the nasal piece of Gardiner Brown's inflating apparatus is also suitable for children (Fig. 22). For self-use by the patient, the nasal piece may be connected with an india-rubber tube, 15 inches in length, which is attached to the mouth-piece

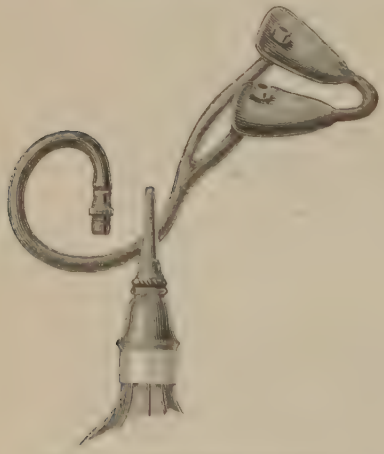

Fig. 23.—Allen's nasal piece and bag.

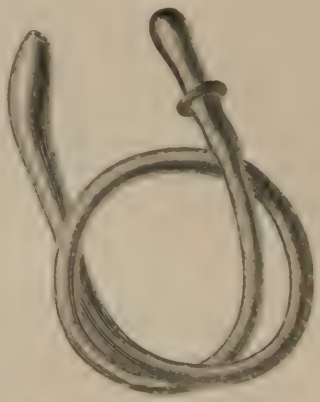

Fig. 24.—Simple inflating tube for children, or for auto-inflation.

of an india-rubber bag. Dr. Peter Allen used a tube with two india-rubber nasal pieces (Fig. 23), which were pressed over the nasal orifices. This avoids the unpleasantness of pushing the tube into the nostril; but, on the other hand, it is not so certain in its effects. An ordinary india-rubber enema-bag of six or eight ounces capacity, with a piece of soft india-rubber tubing covering its hard ivory mouth-piece, suits very well. In the treatment of children there may be substituted for the rather formidable looking air-bag a simple india-rubber tube (Fig. 24), with a mouth-piece for the operator and a nasal piece for the child, and while the

little patient pronounces "hook," or swallows water, the manipulator blows through the tube. This plan can be safely practised by the parent of the child in the intervals between the visits to the surgeon. An adult patient may also practise self-inflation by closing the nostrils firmly over the nose-piece inserted into one nostril, while he himself blows through the tube. Dr. Dundas Grant suggested an auto-inflator in which there is, in connection with the mouth-piece, a space for cotton on which a volatile medicament may be dropped.

Disagreeable Symptoms from Politzerization. Occasionally pain in the stomach is set up, owing to insufficient closure of the pharyngeal cavity, and the consequent passage of air down the œsophagus; but this is immediately relieved by eructation, or by a few full inspirations. Now and then other disagreeable symptoms result from the practice of Politzer's method, such as pain in the head, giddiness, and singing in the ears. These results, however, comparatively seldom follow it.

(C) *VALSALVA'S METHOD OF INFLATING THE MIDDLE EAR.*

Valsalva's method of inflating the middle ear consists in making a forced expiration, with the lips closed and the nostrils firmly compressed with the fingers. In this way, the air contained in the naso-pharyngeal space becomes more or less condensed in proportion to the strength of the expiratory muscles in the given case. Where the resistance offered by the walls of the Eustachian tube or by the tympanic membrane is inconsiderable, the condensed air passes through the Eustachian tube into the tympanic cavity. When the membrane is entire, and where there is much resistance offered by the walls of the Eustachian tube to the passage of air, Valsalva's method is usually quite ineffectual, and even in a normal condition of the middle ear many persons fail to inflate it by this method. Where the membrane is perforated, however, it is more likely to be successful, in consequence of the diminished resistance. Rarely Valsalva's method succeeds in inflating the middle ear after the catheter and Politzerization have failed.

Negative Valsalva's Method. The Negative Valsalva's method, or Toynbee's experiment, consists in swallowing several times, while the mouth and nose are closed. A rarefaction of the air in the naso-pharyngeal cavity is thus produced, and, provided the Eustachian tube is in a normal condition, some of the denser air in the tympanum will pass into the naso-pharyngeal cavity. A sensation of pressure, and sometimes a slight ringing, are experienced in the ear, which are removed when the patient swallows in the ordinary way.

INFORMATION DERIVED FROM THE VARIOUS METHODS OF INFLATING THE MIDDLE EAR.

This information is derived from auscultation, inspection, the sensation of resistance in compressing the inflating bag, the sensations of the patient, and the effects upon the hearing.

Auscultation of the Ear (Fig. 25). Valuable information is derived from the kind of sound produced by the current of air on

Fig. 25.—Auscultation of the ear during catheterization of the middle ear.

the walls and contents of the middle ear. In order to hear these sounds the surgeon must auscultate the ear during the passage of the current, and for this purpose the external auditory canal of the patient is connected with that of the surgeon by an india-rubber tube, thirty inches long, termed the otoscope (Fig. 26), or, more correctly, the auscultation tube, or otophone. This tube is furnished at each end with an ear-piece, one for the use of the surgeon, and the other for the patient. These ear-pieces should have distinctive colours, or shapes, in order that the one for the patient may not be used by the surgeon. Nothing should be allowed to touch or press upon the auscultation tube when in use, while the ear-pieces must not be obstructed with any material, such as wax, in case of interfering with the passage of sound from the patient's ear to the surgeon's.

Fig. 26. Auscultation tube.

Normal Sound. In the normal state of the middle ear the sound heard during inflation has a distinctly blowing character, conveying to the listener the impression as if originating close to his own ear, and as if caused by air striking against a soft yielding membrane. This sound is compared by Politzer to that produced when we place the tongue near to the hard palate, and make a quick expiration, with the lips slightly apart.

Full Dry Sound. If the mucous membrane of the middle ear is abnormally dry, while the Eustachian tube is wide—conditions found in sclerosis of the middle ear—the sound has a full, hard, and dry character.

Râles. Rattling sounds or râles are not infrequently heard. They are produced either by the air passing through fluid secretion, or by the friction of the current of air upon some solid obstructing substance, such as swollen mucous membrane, dried secretion, organized adhesions, etc. When the râles appear to be distant, they probably originate in the Eustachian tube; when, on the other hand, they are heard as if produced in one's own ear, their source is probably in the tympanic cavity. When the râles have a moist or bubbling character, they indicate the presence of fluid secretion in the middle ear. It is to be noted, however, that small quantities of secretion may be in the tympanic cavity without any râle being heard on auscultation. Loud, rattling sounds, like an *r* pronounced roughly, which may be heard even without the use of auscultation, are often produced at the pharyngeal mouth of the Eustachian tube, either by the vibration of the lips of the tube, especially if the catheter is not in proper position, or by the action of the current of air upon the viscid mucus frequently found there. In the latter case the sound is usually only heard at the beginning of the inflation.

Sounds in Eustachian Obstruction. The sound may be thin, weak, distant, interrupted, and attended by a sibilant tone of greater or less intensity and pitch. Assuming that a medium-sized catheter has been used, and that it has been properly inserted into the Eustachian tube, such an auscultation sound generally indicates some form of obstruction in the Eustachian tube or tympanic cavity. The obstruction may be caused by swelling or thickening of the mucous membrane, by dried secretion, by agglutination of the mucous walls, or by organized adhesions. In such a condition a fuller and stronger stream of air is frequently heard to pass into the tympanum, if the patient swallows during the compression of the air-bag. In this way the surgeon obtains the aid of the tensor palati muscle in separating the outer wall of the cartilaginous part of the Eustachian tube from the inner. When there is swelling of the pharyngeal mouth of the Eustachian tube, with indrawn tympanic membrane, a

full thudding sound may be heard, caused by the impact of air and the stretching out of the membrane.

Secondary Sounds. A secondary sound of a crepitating character is sometimes heard after the inflation, either due to the return of the normal membrane after being forced out, or to the retraction of adhesions, cicatrices, etc., which had been stretched.

Perforation Sounds. In perforation of the tympanic membrane the auscultation sounds are often very characteristic. If the perforation is small, and there is fluid secretion in the tympanum, a loud whistling or hissing sound, which may be audible to the bystander

FIG. 27.—Auscultation during Politzerization.

without an auscultation tube, is generally heard, provided the Eustachian tube is freely permeable. A similar sound may be heard when the perforation is large, if the calibre of the Eustachian tube, especially of the tympanic end, is diminished by swelling of the mucous membrane. If the Eustachian tube is wide, and a large part of the tympanic membrane is destroyed, a blowing sound is heard, pretty much like the normal sound, but conveying a stronger impression to the ear of the auscultator. The sounds heard in perforation or destruction of the tympanic membrane have this in common—that they convey to the listener a sense of great nearness, almost as if produced in his own ear, and this is sometimes so marked as to be very disagreeable.

Auscultation during Politzerization (Fig. 27). Auscultation does not yield us so much or so distinct information by Politzer's method as by catheterization, for the sound caused by the act of swallowing the water muffles the weaker sounds in the ear. After long practice, however, the surgeon becomes more able to distinguish the sounds in the ear, and to separate them from external ones; and, further, if the surgeon is here disturbed by the act of swallowing the water, he has the advantage of not hearing the sound produced by the friction of the air in the catheter, or the vibrations at the mouth of the Eustachian tube. The practised surgeon is therefore often able to hear many of the sounds, which have been described as heard during catheterizing, almost as distinctly by auscultation with Politzer's method. Even the unaccustomed observer has no difficulty during inflation by this method in distinguishing the "perforation râle," or the well-marked thudding sound heard when the tympanic membrane returns to its proper position after having been drawn in from obstruction of the Eustachian tube.

Auscultation during Valsalva's Experiment. The information derived in this way is not very important. Its great value is in diagnosing a perforation. A well marked hissing sound, caused by the passage of the air through the perforation, enables us in a simple way to diagnose a perforation in the tympanic membrane. During the negative Valsalva's experiment there is occasionally heard a slight crackling sound.

Value of Auscultation. In regard to the value of auscultation of the ear, as a method of examination, it may be said that, while by itself, without relation to other symptoms, it does not in most cases furnish us with decisive information of the pathological condition of the ear, there is no doubt that, taken in connection with other objective symptoms, it gives important help in the accurate diagnosis of a case.

Inspection of the Membrane during Inflation. By inspection of the tympanic membrane during inflation, we may derive valuable information. During Valsalva's method, if successful, we may see an outward movement of the membrane, especially at the postero-superior part. During the negative Valsalva's method it is sometimes seen to recede. From their more certain effects, more important information is derived from inspecting the membrane during Politzerization or catheterization. We make out in this way the site of a perforation by observing air bubbles being projected outwards during inflation, or thick secretion protruding like a ball from the orifice. If secretion is in the tympanic cavity and there is no perforation, we may see bubbles through the membrane after the inflation, or its colour may change owing to the membrane being freed from the inner wall of the tympanum. When the membrane is indrawn and movable, we may see the unfolding outwards of the membrane with change of colour. A

cicatrix or atrophied portion will be seen to bulge out like a bladder: and, if watched, these bulgings will be seen to disappear shortly afterwards. The general mobility of the membrane may also be ascertained by inspection during inflation. More rarely similar information may be derived during Valsalva's method. The evidence of a perforation is often given in this way.

Ear-Manometer. There are certain contrivances, called ear-manometers (Fig. 28), for showing by ocular demonstration the changes in the density of the air in the middle ear produced by inflation. A simple form consists of a fine glass tube, having the shape of a horse-shoe. This is fitted air-tight into the external auditory canal by means of an india-rubber plug. A drop of red ink, or a solution of carmine, is placed in the tube near its outer end. The falling and rising of the coloured solution indicate the fluctuations in the pressure of the air in the middle ear.

Fig. 28.—Ear-manometer.

Sensations of the Patient during Inflation. The sensations of the patient as to whether the current of air penetrates to the tympanum are not always to be depended upon. A sensation of fulness in the ear is often experienced, continuing, with sometimes a feeling of dulness, for a short time afterwards. In many cases, where by auscultation we know that the air has entered the tympanum, the patient seems to have no sensation in the ear. On the other hand, the patient sometimes says that he feels it in his ear, when we know that it has not penetrated to the tympanum. Many patients, however, have a correct appreciation of the sensation, and can tell when the operation is, and when it is not, successful. During catheterization, when the air passes freely as far as the membrane, the patient feels as if the air passes out of the ear; on the other hand, when the air does not reach the tympanum, the patient often says that it only passes towards, but not so far as, the ear. In children, we may know that Politzer's method is efficient by the child suddenly raising his hands up to his ears—due to the marked sensation which is often felt during inflation in the catarrhal affections of childhood.

Effects of Inflation upon the Hearing and Subjective Sounds. Valuable information is frequently obtained regarding the nature of the disease, from the effects of inflation upon the hearing and subjective sounds. If, for example, in a case of non-perforative catarrh of the middle ear, successful inflation produces no effect upon the hearing, or increases the deafness for a time, the prognosis is unfavourable. If, on the other hand, distinct improvement is at once manifested, and especially if it continues for several hours or a day or two, the prognosis is favourable, as we then have probably to do with an exudative catarrh not attended by serious structural changes in the middle ear. So again in a purulent disease of the middle ear with perforation,

improvement after inflation indicates the probability of permanent improvement in the hearing. If the improvement lasts for only two or three minutes, there are probably adhesions—pseudo-bands, retraction of the tendon of the tensor tympani, or atrophy—the temporary stretching causing a momentary improvement.

Sensation of Resistance. Palpation, or the sensation of resistance to the hand during the pressure of the bag in the use of the catheter, shows in some measure the amount of obstruction in the tube, provided the point of the instrument is properly inserted in the mouth of the tube. During Politzer's method we can tell by the sensation of resistance if the soft palate has closed accurately and the inflation has been successful.

IV. METHODS OF TESTING THE HEARING POWER.

We shall consider the tests to be applied, (A) By air-conduction, and (B) By bone-conduction.

(A) *TESTS APPLIED BY AIR-CONDUCTION.*

In testing by air-conduction each ear should be tested separately while the opposite ear is closed and the eyes are shut.

The tests by air-conduction are (*a*) simple tones, and (*b*) speech.

(*a*) **Simple Tones.** Unfortunately we are not yet possessed of a universal standard by which we may measure and compare the hearing power of an individual. The most convenient instruments for testing the capacity for hearing simple tones are the watch and Politzer's acoumeter; but both of these are defective in this respect, that they only test the power of the ear for hearing one or two tones. The human ear is capable of perceiving a vast number of different tones or sounds, but in using the tick of a watch we are only testing with two particular notes, and it is quite conceivable that the power of hearing these two notes may be very defective, while the power of distinguishing many others may be comparatively good, and *vice versâ*.

Watch Test. We must employ a watch the tick of which is a clear distinct sound, not a rubbing or shuffling tick. We must keep in mind that the tick of a watch is louder after winding, while it is fainter after cleaning and oiling. A stop-watch is the best, as with it we may at any moment stop the ticking, and in this way we are able to check the veracity of the patient. This precaution is specially necessary in the examination of children. As watches differ very much in pitch and intensity of tone, the particular watch used for the purpose should be tried on a number of persons having good hearing. The distance in inches, at which the tick is heard by a person of good hearing power, is termed the *normal* hearing

distance, and forms the standard in testing the hearing power of patients. Thus, if the normal hearing distance of a given watch is 36 inches, and the actual hearing distance of a patient is 20, this fact would be expressed by the fraction $\frac{20}{36}$. This is a very convenient and simple way of expressing, in the record of a case, the state of the hearing power. If the tick is not heard even when the watch is pressed on the ear, we express the condition of hearing as $\frac{0}{36}$; if heard on pressure, as $\frac{0}{36}$; while, if the watch is heard on slight contact, as $\frac{0}{36}$. To ensure accuracy we should use a measuring rule, which must not be touched by the watch, while we are testing the hearing. We should first hold the watch close to the best ear, so that the patient may know the character of the sound, and thus be able to distinguish it from other sounds, especially from subjective ones. The ear which is not being tested should then be carefully closed, and the watch held, parallel with the auricle, beyond the hearing limit, and then brought gradually nearer to the ear until we find the exact hearing distance. In some patients we get very contradictory statements as to the distance at which the tick is heard. While imagination has something to do with this, it is to be remembered that there is, in special forms of labyrinthine deafness, an uncertain zone of hearing.

Politzer's Acoumeter. This (Fig. 29) consists of a pillar of vulcanite (*a*) rather more than an inch in length, into which are fitted an immovable cylinder of steel (*c*), about an inch in length, and a short distance above this a movable lever about an inch and a half in length, with a longer arm terminating in a small ball (*b*), so as to form a percussion hammer, and a shorter arm (*e*), pressure on which raises the hammer. The vulcanite pillar is held between the index finger and the thumb, and, the shorter arm of the lever being pressed down by the middle finger, the longer arm with the percussion hammer is raised to a fixed height, and, being allowed to fall on the steel cylinder, a sharp click is produced. As the height of fall and the dimensions of the instrument are the same in all cases, the amount of sound is uniform. In the vulcanite pillar, above the percussion hammer, is a perforation for the insertion, when required, of a metal pin, four centimetres in length, having the free extremity terminating in a round metal plate (*d*). This pin is

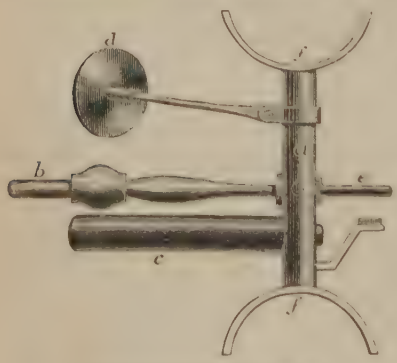

FIG. 29.—Politzer's acoumeter.

intended to be used when testing the perception of sound conveyed through the bones of the head by pressing the metal plate on the temporal bone, or the mastoid process. With the greatest care, after excluding all disturbing elements, the normal hearing distance for this instrument has been found to be fifteen metres, about sixteen yards. The intensity of the click of the acoumeter, being so much greater than the ticking of any watch, makes it possible to determine the degree of sharpness of hearing in many cases where the tick of the watch cannot be perceived. Its chief value is to test the hearing in persons whose deafness is so great that the tick of a watch cannot be heard.

Galton's Whistle (Fig. 30) is useful for testing the patient's power of perceiving the pitch of notes. It has a very fine bore, furnished with a movable plug by which the tube can be at will shortened or lengthened. A small india-rubber ball is attached, by which the air is blown into the tube. By lengthening the tube the pitch is lowered, by shortening it the pitch is raised. By measuring the length of the open tube and referring to a table which is provided, we can tell the exact number of vibrations of the note.

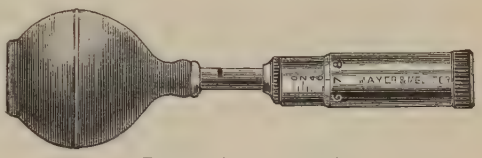

FIG. 30.—Galton's Whistle.

König's rods and tuning-forks of different pitch, such as C, C^1, C^2, C^3, C^4, D^4, are also employed for testing the power of perceiving pitch.

Testing very Deaf Children. When testing a young child, in whom complete deafness is suspected, we may employ the sound of a bell, a sharp whistle, or a very loud tone of voice, taking care that the child does not see the source of the sound.

(*b*) **Speech.** In testing the hearing by means of speech, the ear should be turned towards the examiner, while the opposite ear should be carefully stopped, and the eyes of the patient should be shielded or turned away, so as not to see the face of the speaker.

Whispered Voice. A whisper is more suitable for testing the hearing than loud speaking, not only because we can maintain a greater uniformity at different and distant times, but also because in one-sided deafness, the whispered voice is not so likely to be heard through the good ear, or through the bones of the head, and, further, in whispered speech the disparity between the sound of vowels and that of consonants is less marked. In normal hearing, a whispered word should be heard, if we exclude all other sounds, at a distance of about twenty-five yards. To avoid guessing by the patient, it is well to pronounce single words and not sentences, the patient repeating them word for word after the examiner. It must

be remembered, however, that whispers may vary very much in loudness and distinctness. For the limited size of a consulting room, it is well to cultivate a low uniform whisper, and make the distance at which it is heard by a person of normal hearing our standard. If this were twelve feet, and a particular patient heard it only at three feet, we would express it $\frac{3}{12}$. We should not repeat the same words on different days. Familiar words are heard by deaf persons at a greater distance than words which are not well known; and hence the distance at which words of a foreign tongue are heard is sometimes only $\frac{1}{3}$th or $\frac{1}{4}$th that of the mother tongue (Politzer). If the deafness is very great, however, the conversational or even loud-spoken voice must be used.

Vowel Sounds. Vowel Sounds, it is well known, are heard much more clearly than consonants. Oscar Wolf, of Frankfurt-on-Maine, has investigated very thoroughly the acoustic characters of the different elements of speech. His researches show the relative distance at which the vowel and consonant sounds can be distinguished when loudly sounded. If the vowels and consonants are pronounced as in German, and the distances expressed in paces, the highest and richest in tone is *a* (*ah*), which is heard at a distance of 360 paces; while the lowest and feeblest is *h* aspirate, heard only at 12 paces. Between these extreme limits Wolf found *o* = 350, *ei* and *ai* = 340, *e* = 330, *i* = 300, *eu* = 290, *au* = 285, *u* = 280, *sch* = 200, *s* = 175, *g* and *ch* soft = 130, *ch* rough and uvular *r* = 90, *f* and *v* = 67, *k* and hard *g* = 63, *t* and *d* = 63, *r* lingual = 41, *b* and *p* = 18.

Simulated Deafness. The detection of simulated or exaggerated deafness is often difficult, particularly if *total* deafness is simulated. In continental countries, where compulsory military service exists, this form of malingering is much more common than in this country. To make the deception more easy, foreign bodies are pressed into the ear, or caustic substances applied to the canal. An objective examination should in the first place be carried out. When the person does not feign *total* deafness, the hearing power should be accurately tested and noted while he is blindfolded, and comparisons made at intervals, when the great disparity in the apparent hearing, as stated by the patient, who does not see how far he hears, reveals the true state of matters. When there is feigned *total* deafness, it is more difficult to expose well-planned deception. Such expedients as observing if loud speech awakens the individual out of sleep, if opprobrious statements made in his presence have any effect on his features, or the effect of informing him "to go, as he is unfit for work," etc., may be tried. In a case under the author's care, that of a young woman, the simulation was discovered by observing that one afternoon she sung the identical songs which had been sung by the servant in the forenoon of the same day. When we have to ascertain if total unilateral deafness exists, it is a good plan to cause the supposed malingerer to apply

to his ears a double-tube stethoscope, having the tube for his hearing ear plugged. When the cup-shaped end of the stethoscope is spoken into, the person will probably say he hears. If the tube is now removed from the hearing ear, and the latter closed with the finger, he will say that he no longer hears, knowing as he does that the hearing ear is shut, while the tube of the stethoscope is only in the ear, with which he pretends to be deaf.

(B) *TESTS APPLIED BY BONE-CONDUCTION.*

Bone-Conduction of Sound. Supposing the ears were sealed up so that sound could not find admission by these channels, if a tuning-fork were made to vibrate, no sound would be heard, provided a space of air, however small, existed between the head and the fork. But if the vibrating tuning-fork were placed in contact with the head, its note would be heard resounding even more loudly than if the ears were open. Similar exaggeration of the impression of sound may be noted in our own persons, when, in the act of speaking, we close the ears; the vibrations of the vocal apparatus, transmitted by the cranial bones, will then affect our auditory nerves much more strongly. The vibrations of the tuning-fork are communicated to the bones of the head, and are transmitted to the osseous casing of the cavities of the ears, from which they pass to the endings of the auditory nerve in the labyrinth. In testing sound perception through the bones of the head, a tuning-fork or a loudly ticking watch may be employed.

FIG. 32.—Gardiner Brown's tuning-fork.

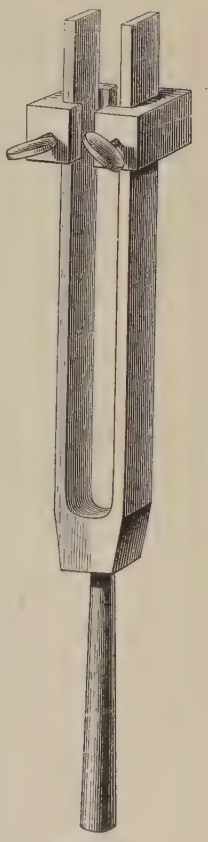

FIG. 31.—Tuning-fork with clamps.

Tuning-Fork Test. The tuning-fork yields by far the most reliable results. The tuning-fork (Figs. 31 and 32) most useful for our purpose should be large-sized, and of the pitch C, with 512

vibrations in the second, fitted to produce a sound sufficiently long continued to ensure that the patient has time to recognize on which side he hears the sound best. It yields two simultaneous sounds—the fundamental or deep tone, and the high tones or harmonics. The harmonics are usually appreciated more distinctly when the fork is held some distance from the ear; the fundamental tone predominates when it is held nearer. The harmonics are in great measure destroyed, when the limbs of the tuning-fork are grasped by two brass clamps. When these are attached, only one tone is appreciated, and that one, on account of the number of vibrations per second being diminished, is much lower in the scale. By shifting the clamps towards the handle we render the pitch higher, until, when we reach the lower end of the limbs of the fork, it is raised a complete octave. In this way one tuning-fork, with the addition of these clamps, can produce a variety of notes according to the position of the clamps.

Watch Test. In testing bone-conduction with the watch the ears should be closed by the patient's fingers, and the watch applied first to the temple, and then to the mastoid process. The sound of even a loudly ticking watch may not be heard, when applied to the bones of the head, although the perceptive power of the auditory nerve is unimpaired: but, if a weakly ticking watch is clearly heard, this indicates that the sentient part of the ear is pretty healthy.

The usual methods of employing the tuning-fork are those of *Weber* and *Rinne*.

Weber's Test. Weber's method is based upon the following experiment. If one ear be closed, and a sounding fork placed in contact with the middle line of the head, such as the bridge of the nose, the forehead, or the vertex, the effect will be very striking—the sound heard in the closed ear will be much louder than in the open one; indeed, it will be so intensified on the closed side as to give the impression that no sound is perceived in the open ear at all. Even though the fork, still in contact with the head, be moved close to the unoccluded ear, the sound will still be heard almost exclusively on the closed side. It is noteworthy that, in stopping the ear, if the finger be pressed *firmly* into the external meatus, the increase of sound is less marked than when there is closure with only slight pressure; or the sound, instead of being increased, may be actually diminished. The same effect, which is brought about by Weber's experiment, is produced by many of the diseases of the sound-conducting apparatus. The obstructions, due to pathological changes in the external auditory canal and tympanum, which prevent the entrance of the waves of sound to the fluid of the labyrinth, also intercept, in their passage outwards, the vibrations which have been conducted to the labyrinth by the bones of the head: and these vibrations, being reflected back on

the nerve, intensify the sound of the tuning-fork. Hence, the vibrating fork may be only faintly heard when held opposite to the dull ear; but, when transferred to the bones of the head, it will sound much more strongly, or even exclusively, on that side. In *Weber's test* there is a source of error against which we must be on our guard. The patient being preoccupied by the thought that he should hear the tuning-fork better on the good side, and worse on the deaf one, will probably, if not previously cautioned, at first say that he hears it better on the healthy side. In most cases, however, with moderately intelligent patients, we will, by a little exercise of patience, succeed in getting an accurate account.

The obstructions in the auditory passages to the entrance or exit of waves of sound may consist simply of the presence of foreign substances, such as impacted cerumen in the meatus, or catarrhal exudations into the tympanic cavity. The same effect is produced, however, by any cause which interferes with the vibrating or oscillating power of the membrana tympani and ossicular chain, such as their increased tension, caused by the stronger effects of the atmospheric pressure on the outer surface of the membrane in obstruction of the Eustachian tube, or in anchylosis of the ossicles to one another, or of the plate of the stapes to the edge of the fenestra ovalis. In the case of perforation of the membrane, the increased perception of sound, conducted by the bones, generally observed, is due to other changes in the tympanum, such as thickening of the mucous membrane, rigidity of the ossicles, or the presence of purulent secretion.

Explanation of Weber's Test. A great amount of labour, by way of experiment and otherwise, has been expended to explain this phenomenon. Politzer gives the following reasons: 1st, The increased resonance of the external auditory canal, and the reflection upon the tympanic membrane and ossicles of the vibrations transmitted by the bones of the head to the air in the external passage; 2nd, the hindrance to the passing away from the ear of the waves of sound conducted by the bones of the head to the labyrinth and tympanum; 3rd, the altered tension of the membrane and ossicular chain.

Rinne's Test consists in applying the vibrating tuning-fork with moderate pressure to the surface over the mastoid process, and, after holding it in that position until the sound has completely died away, transferring it rapidly opposite to, but so as not to touch, the orifice of the ear. If the note of the tuning-fork again becomes audible, the result is said to be positive ($+ R$), the condition in normal hearing. When, on the contrary, the sound of the tuning-fork remains inaudible after the transference, the result is said to be negative ($- R$), bone-conduction being in excess, as in many cases of disease. For the sake of accuracy the time in seconds should be observed and noted during which the tuning-fork is heard by bone-conduction after it has ceased by air-conduction, or during air-conduction after it has ceased by bone-conduction. The duration

of the air-conduction and the duration of the bone-conduction should be compared with the normal standard.

Self Comparison. We may also form a fair estimate of a patient's bone-conduction by comparing his appreciation of the tuning-fork applied to the head with that of our own, provided that our nerves of hearing are normal.

H. E. Jones, of Liverpool, suggests that we may determine the size and the condition of the antrum and other mastoid spaces by listening through the auscultation tube while a vibrating tuning-fork is placed on different parts of the mastoid. The tone, modified by the resonance of air-filled spaces, will distinguish them from dense bone.

Gellé's experiment consists in applying the tuning-fork to the bones of the head, while the air in the external auditory canal is condensed by means of a suction apparatus. In the normal state the tone is thus diminished owing to increased labyrinthine pressure due to pushing in of the ossicular chain upon the labyrinthine fluid.

In *Gruber's* test, after the tuning-fork has ceased to be heard by air-conduction, it is applied to the finger closing the ear, when the sound is again heard.

Acoustic Reaction to the Galvanic Current. The perceptive capacity of the auditory nerve is sometimes determined by the acoustic reaction to the galvanic current. Brenner asserts that there is a constant law of reaction of the nerve by sensations of sound to the galvanic current. When the negative pole is placed in fluid filling the canal of the ear, a loud sensation of sound is heard by the patient on closing the circuit, continuing till it is opened, when it ceases. On the other hand, if the positive pole is placed in the fluid, no sound is heard on closure, but a feeble sound is heard at the moment of opening. If the auditory nerve is abnormal, there is a deviation from this law. If a very weak current excites a loud sound, there is hyperaesthesia; if a strong current has little or no effect, there is dysaesthesia. These conclusions are denied by Schwartze, Wreden, Schulz, etc. And it may be said that the diagnostic value of the galvanic current in ear disease is still *sub judice*.

CHAPTER II.

SYMPTOMATOLOGY.

The symptoms of ear disease will be considered in the following order, the first five being probably the most frequent and important.

I. Disturbance of hearing.
II. Subjective sounds in the ear (Tinnitus Aurium).
III. Discharge from the ear.
IV. Pain in the ear.
V. Vertigo, or giddiness, and staggering.
VI. Sickness and vomiting.
VII. Abnormal sensations in the head.
VIII. Disturbance of the sensorium.
IX. Pyrexial symptoms.
X. Disturbance of sight, smell, and taste.
XI. Nasal and throat symptoms.

I. DISTURBANCE OF HEARING.

We shall describe under this heading, (A) disturbance by air-conduction; (B) disturbance by bone-conduction; (C) consequences of defective hearing.

(A) *DISTURBANCE OF HEARING BY AIR-CONDUCTION.*

Simple Defect of Hearing. - This is one of the most frequent symptoms of disease in the ear. Patients often believe that they hear quite well, when the application of tests shows a real defect in one or both ears. The degree of impairment may vary from a defect so slight that the patient is unconscious of its existence, to total loss of hearing; but the latter is very rare even in deaf-mutes, of whom a large proportion hear very loud sounds, such as a loud bell, or an explosion. In very many patients both ears are affected, although one is usually worse than the other, the less affected one being often thought by the patient to be perfectly good.

It is often difficult to draw from the patient a correct account of the origin and progress of the defective hearing. He may say six months as the duration, and afterwards admit that the hearing has not been good for years.

Defects of hearing may be connected with a great variety of pathological conditions. Affections of the middle ear are, however, the most common, although the most serious forms of deafness are due to disease in the nerve structures or labyrinth. Persons with defective hearing have a singular tendency to deny the existence of the defect, or, at any rate, to minimize the degree of it. Only when the deafness is so prominent that it would be absurd to ignore it, do they admit its existence. When friends suggest dulness of hearing, the blame is laid upon the indistinctness of the speaker; and there is no doubt that the prevailing slovenly enunciation of words adds very much to the difficulty of persons dull of hearing.

Lip-reading. We are sometimes very apt to acquire a wrong impression of the degree of the deafness by not taking into account the effects of lip- and face-reading—the help given by the eye. It is well known that deaf persons may acquire great aptitude in reading the lips, and in guessing the meaning of what they do not hear from the sense of what they do hear. They are surprised at the degree of their deafness when tested while their eyes are closed or turned away from the speaker. This accounts for the fact that deaf persons often appear to hear worse at the time of dusk, when sight cannot give effective aid; and hence also they are less able to understand bearded and moustached men, from the greater difficulty of seeing the movements of the lips, than persons with bare faces. Some deaf persons acquire extraordinary power of reading the facial movements, and, indeed, this is the basis of the German method of educating deaf-mutes. Only by careful testing of the hearing of each ear separately, both with an acoumeter and with speech, as already described (p. 27), can we properly estimate the extent of the deafness.

Word-deafness. The hearing of words or speech may be very defective in certain cases, while the hearing of a mechanical sound, such as the tick of a watch, or music, or the falling of a pin, is good. A watch-tick may be heard at almost the full distance from the ear, although loud speech may require to be uttered close to the ear before it is heard. Another form of word-deafness has been described by Broadbent and others, due to disease in the cortex of the left temporal lobe of the brain, where the organ of hearing is apparently healthy, and where, although patients hear speech, they are unable to understand it. Patients often say they hear the sounds quite well but cannot gather the meaning. This power of forming

word pictures, apart from ordinary hearing, seems to be resident in the first convolution of the left temporal lobe.

Deafness to Mechanical Sounds. Here we have the opposite condition from that found in word-deafness. There is defective hearing for the tick of a watch or other mechanical sounds, while there is comparatively good hearing for words or speech. There is frequently a striking want of agreement between the hearing capacity for the watch and that for speech. A patient may hear lightly-spoken words at a considerable distance, and yet not hear the watch even when in contact with the ear. Sometimes, in a patient with both ears affected, the hearing of conversation is better on the side where the hearing of the watch is worse. In the treatment of deafness, we occasionally find this disparity very marked, and the hearing of speech may distinctly improve, while the hearing distance for the tick of a watch may remain unchanged or even, as has been observed, actually become less; or the contrary may be observed. Persons who have become deaf in later life usually hear speech better in proportion than the watch, while the opposite holds good with those who have become deaf in childhood. Probably the greater knowledge of language in the former, as well as experience in reading the facial movements, partly accounts for this difference.

Partial Tone-deafness. It is most common for deaf patients to hear high tones best, such as a woman's or a child's voice, but occasionally we meet with persons who hear deep tones best. Many persons, especially those over sixty years of age, whose hearing may otherwise be regarded as normal, have a defective capacity for hearing notes of a very high pitch, such as the chirping of a cricket. An elderly gentleman, who loved the songs of birds, remarked that he first lost the song of the lark. This defect is also often noticed in persons, such as boilermakers, who have for long worked amid noisy surroundings. This diminished power of hearing notes of a high pitch seems to be generally associated with affections of the labyrinth. The greater capacity which some patients have of hearing the tick of a watch (comparatively high note) better proportionately than speech (comparatively low note) may be partially due to this peculiar defect. Partial tone-deafness is usually looked upon as evidence of disease in the basilar membrane of the cochlea; but it may be connected with changes in the tension of the tympanic membrane and ossicular chain. The assumption is that a morbid condition of the longer fibres of the basilar membrane disturbs the correct perception of the low tones (bass deafness), while an abnormal condition of the short fibres impairs or destroys the power of correctly recognizing high tones.

False Tone-perception (*paracusis* and *diplacusis*). We occasionally find that the ear interprets the tone incorrectly; instead of the real tone proceeding from the sounding body being heard, a sound may be appreciated, which is a half tone, a complete tone, a third, or an octave higher or lower. This is *paracusis* or false hearing. If only one ear be affected, we have the phenomenon of *diplacusis*: a double tone is heard, namely, the true one on the normal side and the false one on the affected side. In these various anomalies of hearing, particular fibres or groups of fibres of the basilar membrane may be supposed to be in some way disturbed. In the hearing of a double tone, probably the fibres of the basilar membrane on the two sides corresponding with each other do not vibrate co-equally. Thus, supposing the sounding object vibrates 600 times in a second, the fibres on the normal side, which are in exact unison, vibrate that number of times, while the corresponding ones on the opposite side from some defect vibrate say 450 times in a second.

Another form of peculiarity is sometimes met with in the perception of tones, namely, the perception of the same tone twice over, or the hearing of a tone for a short period after the objective sound has ceased.

Defective Perception of Locality of Sound (*paracusis loci*). This is the inability to distinguish the direction of sound. This anomaly is generally connected with unilateral deafness, since the power of localizing sound is probably the result of binaural hearing. If the person is deaf in one ear, the report of a gun on that side may appear to him to be coming from the opposite side, a peculiarity which, in certain circumstances, may be fraught with danger.

Excessive or Painful Hearing (*hyperæsthesia acoustica*). Extreme sensitiveness to sound, especially sounds of a very high pitch, occurs in a variety of circumstances. In fevers, in the early stage of inflammation of the middle ear, in hysteria, in migraine, in persons who sleep lightly, and for a short time after the removal of a plug of cerumen which had caused great deafness, there is sometimes an unpleasant or even painful perception of sound, which may be limited to particular notes, especially those of high pitch. Even in persons who may be very deaf, loud sounds, such as speech through a conversation tube, or a railway whistle, or loud music such as that of a large organ, are sometimes very disagreeable or even painful.

Hearing better in a Noise (*paracusis Willisii*). In most deaf persons, absolute silence and stillness of the surroundings favour the hearing of spoken words or other sounds; but it has been long known that in certain forms of ear disease the patient hears better in a noise. This peculiarity is termed *paracusis Willisii*, because Willis, in 1680, first described a case, in which a husband could be heard by

his wife only while the servant was beating a drum. Not unfrequently deaf persons hear much better when travelling in a railway carriage, or while in the presence of noisy machinery, than in complete stillness. Some writers try to explain such an apparent paradox by pointing out that in a railway carriage the confined space, the nearness to the speaker, the elevation of the voice, and the close attention of the listener may account for the apparently better hearing. This matter has, however, been put beyond dispute by the observation of Politzer and others, including the author, that the tick of a watch or the click of the acoumeter is actually heard by some deaf persons farther away from the ear in a railway carriage than in a quiet room. The probable explanation is the one given by Politzer, namely, that it is the result of the severe shaking of the ossicles, when their joints have become stiffened by a catarrhal process. In this way the small bones are made fitter for the transmission of sound. This symptom usually denotes that the cause of the deafness is in the middle ear and not in the labyrinth.

(B) *DISTURBANCE OF HEARING BY BONE-CONDUCTION.*

With the ears open, this mode of conduction is somewhat feebler than the ordinary method of hearing through the air. For we find that, after a vibrating tuning-fork placed in contact with any part of the head has ceased to be heard, it will again become audible if transferred to a point opposite to, but not touching, the orifice of the ear. In a normal state of the hearing, therefore, sound waves conducted by the bones to the nerve of hearing produce a less effect than when conducted by the air. But with deaf people this is often reversed, and they may hear much better by bone-conduction.

Utility of Bone-conduction. When the conducting part of the organ of hearing is diseased, bone-conduction of sound may be turned to profitable account by patients, and the tones of a musical instrument, such as the piano, may sometimes be appreciated by a very deaf person, if a rod of wood, in contact at one end with some part of the instrument, be held at the other end between the teeth of the patient. In this way a melody, which would be a confused mass of sound under ordinary circumstances, may be heard clearly. The author has been informed that when engineers wish to test the smooth working of a piston they place one end of a measuring rule upon the outside of the cylinder and hold the other end between the teeth, while the ears are tightly closed with the fingers. This is also the basis of the use of the audiphone, an artificial aid to hearing (see p. 84). In like manner, the movements of mastication and the sound of their own voices—*autophonia*—are heard much louder by patients

suffering from certain forms of deafness. Such patients often say that they cannot hear during mastication.

Information from Weber's and Rinne's Tests. By Weber's test (see p. 32) important information may be gained. In a general way, liable no doubt to exceptions, it may be said that, if the vibrating tuning-fork be heard more strongly on the affected or deafer side, that is when bone-conduction is in excess, the nerve on that side is fairly healthy, and the patient is probably suffering from disease of the external or middle ear. While, on the other hand, if there be diminished perception of the tuning-fork on the affected or deafer side, there is probably some lesion of the labyrinth or auditory nerve.

With respect to Rinne's test (see p. 33) it may also be said in a general way that, when the bone-conduction predominates over the air-conduction (result, negative), the obstacle to hearing is in the external or middle ear, and that, when, on the contrary, the air-conduction predominates (result, positive), we may infer that the labyrinth or auditory nerve is the seat of the mischief. Weber's test is probably the more reliable of the two.

Self Comparison. It may also be assumed that the perceptive power of the patient is fairly good, if, the moment he has ceased to hear the sounding-fork applied to his mastoid process, we quickly transfer it to our own and also fail to perceive it, or hear it only slightly. If, on the other hand, we can distinguish it clearly, and for some time after the patient no longer hears it, we may conclude that his auditory nerves have lost their normal susceptibility to sound.

Effects of Age on Bone-conduction. In employing these tests, it is to be remembered that, as pointed out by von Troltsch, in persons over fifty years of age, diminished perception of vibrations conveyed along the bones has not the same serious meaning as in younger people, for after that period of life it is often due to some change in the osseous tissue of the cranial bones, which impairs their conducting power.

Disturbing Influences in Weber's and Rinne's Tests. There are no doubt many exceptions to these conclusions as to the value of Weber's and Rinne's tests. We have often to deal in practice with mixed affections of the external, middle, and internal ear, so that there may exist in the one person simultaneous affections of the conducting structures and of the nerve structures, the affection of the one region (in its influence on the bone-conduction) counterbalancing or more than counterbalancing that of the other region. This seems to be the true explanation of the frequent failure of the expected predominance of the bone-conduction over the air-conduction, or of the air-conduction over the bone-conduction. We may find, for example, on examining the ears of a man very dull of hearing, that, while there is an undoubted affection of the conducting structures, the air-conduction, by Rinne's test, predominates. On inquiry,

however, we may find that this man works at boilermaking or riveting, and that, as a consequence of the loud sounds, the nerve structures of his ears are damaged, and his perception by bone-conduction in this way so much enfeebled as to more than counterbalance the effects upon the bone-conduction of the disease of the conducting structures. On the other hand, a patient may have unmistakable signs of nerve mischief, and yet the bone-conduction by Rinne's test may predominate over the air-conduction. After the removal of a plug of cerumen, the relation between the bone-conduction and the air-conduction may be reversed, so that the air-conduction may exceed the bone-conduction. The plug of cerumen reinforced the bone-conduction to such an extent as to more than neutralize the enfeebling influence upon the bone-conduction of diseased nerve structures. Predominance of the air-conduction does not therefore exclude disease of the conducting structures, but may simply mean that there exists in the nerve structures a condition which more than counterbalances the mischief in the conducting structures, while predominance of the bone-conduction does not necessarily exclude mischief in the nerve structures, but may simply indicate that there exists in the conducting structures, a condition which is sufficient to more than counterbalance, in regard to the bone-conduction, the effects of the nerve disease. It may be mentioned that in experiments carried out by the author, in purulent forms of disease of the middle ear, he found scarcely an exception to the rule that by Weber's and Rinne's tests bone-conduction was in excess.

(C) *CONSEQUENCES OF DEFECTIVE HEARING.*

Deaf-mutism. We may generally regard deaf-mutism as a symptom of ear disease, as it is in the vast majority of cases simply a consequence of total, or of a high degree of, deafness, which has either been congenital, or has originated in the early years of life. Deafness for speech, coming on under four years of age, is certain to be attended by dumbness, and even between four and eight years of age, if great care is not exercised, serious deafness is liable to be followed by loss of speech. The importance of the subject of deaf-mutism, however, has led the author to devote to it a special chapter, to which the reader is referred.

Defective Articulation. In less severe forms of deafness in a child, while mutism may not result, a less perfect articulation is very early observed, as he fails to hear all the shades of sound which make up articulate speech. The effect is thus to render the pronunciation indistinct and undefined. If, however, the deafness becomes more aggravated, or if the child is very young and has only recently attained a slight knowledge of speech, the pronunciation becomes more and more imperfect, and, his knowledge and memory of words being insufficient to keep what he has, he may cease altogether to speak, or his utterance may be confined to unintelligible sounds. The child, unlike the adult, ceases to make any effort to hear, and finds it more easy to trust to signs, in the use of which he is usually encouraged by the parents. After a time,

the parents, regarding the child as quite deaf, believe that it is useless to speak to him at all, and resort more and more to gestures, till the child comes to be classed as a confirmed deaf-mute. If the parents took pains to speak in a loud and distinct voice near to the ears of the child, as they would to a deaf adult, and by that means maintain and even increase the child's knowledge of words, the consequences might be much less serious.

Defective Mental Development. As the result of the examination of six hundred school children, the author found twice as many with defective hearing among the backward children as among the forward children. There is no doubt that by the loss or distinct impairment of hearing in youth, the mental faculties become damaged: and, even although hearing should return after some years, the baneful effects upon the mental development of the child of having been partially or wholly shut out from sound at the most valuable educational period of life can never be thoroughly repaired. The results of impaired hearing in youth upon the adult are thus described by von Tröltsch: "Men, who in early youth have suffered from impaired hearing, have, in many cases, as a consequence, something unstable, confused, or undecided, in their disposition and character. They are undecided and faltering in action, illogical and changeable in thought and speech, their answers often not being to the point. An experienced and observant physician can thus, in many cases, after a short conversation, even from the speech and manner of a patient, discover that most probably he had in youth defective hearing."

II. SUBJECTIVE SOUNDS IN THE EAR (TINNITUS AURIUM).

This symptom may be defined as the perception of sounds in the ear or head which have no objective cause outside the body. It is generally, although not invariably, associated with defective hearing, and is a symptom of many and varied diseases and disturbances of the auditory apparatus. It is extremely common. Of 846 consecutive cases of ear disease recorded in connection with the Glasgow Ear Hospital, this was complained of in a greater or less degree in 502 cases, or about 60 per cent. of the whole. It is not unfrequently the only symptom noticed by the patient, and he often regards defective hearing as caused by the distraction of the noises in the ear. The sounds may conveniently be divided into two classes: first, those in which no vibrating body really exists in the ear, and, second, those due to the actual presence of sonorous vibrations, originating either in the interior of the ear or in the structures in its vicinity. The sounds comprised in the second

class are, properly speaking, objective; but they are usually included under the term subjective sounds.

The character of these sounds, their situation, their constant or intermittent character, their relation to the defective hearing and to mental disturbance, and their causes, are taken up in detail in the chapter specially devoted to this subject.

III. DISCHARGE FROM THE EAR.

Probably about a third of all diseases of the ear coming before the surgeon are attended by discharge, which is generally due to purulent or perforative inflammation of the middle ear. Of 14,000 cases treated at the Glasgow Ear Hospital 4000 presented this symptom. The term "otorrhœa" is applied to conditions attended by this symptom; and, with comparatively few exceptions, there is perforation of the tympanic membrane, though in a small number of cases it is due to inflammation of the external auditory canal, especially eczematous inflammation. While there is frequently pain at the early stage, in a large number of cases no pain is complained of. It is generally attended by more or less defective hearing, and in most cases it has existed for many months or even years before coming under the surgeon's observation. The discharge may be very slight in quantity, so as *even to escape the attention of the patient*, or to be mistaken for thin wax, or it may be such as to fill the canal very soon after syringing and drying.

Character of the Discharge. In character also it varies. It is most commonly muco-purulent. It may, however, be serous-looking, especially in the early stage of an inflammation of the middle ear, or when due to eczema of the ear. The mucous element may predominate, giving the secretion a tenacious or stringy character, or there may be almost pure pus, which imparts a milky colour to the water used in syringing. It is sometimes tinged with blood, especially when there are granulations or polypi in the ear. It has frequently an offensive smell, especially when there has been no attempt at cleansing, and in very chronic cases its odour sometimes resembles that of old cheese.

The conditions associated with discharge from the ear are fully described under the objective symptoms of purulent inflammation of the middle ear. The dangers associated with this symptom are described in the chapter on "Consequences of Purulent Inflammation of the Middle Ear." In all cases attended by discharge from the ear, objective examination is essential; and, in order to acquire a proper knowledge of the exact condition, it is always necessary to syringe and dry the inside of the ear before using the

mirror and speculum. Where there is a history of a past discharge, which may have been absent for a length of time, we often find a dry perforation, or a cicatrix, or a calcareous deposit.

IV. PAIN OR OTHER UNPLEASANT SENSATIONS IN THE EAR.

Pain is a frequent symptom of ear disease. We may conveniently distinguish two varieties: 1st, pain associated with an inflammatory process; 2nd, pain without any evidence of inflammation.

Inflammatory Pain. The first variety is obviously connected chiefly with *acute* inflammation, especially with acute inflammation of the middle ear (purulent or non-purulent). The earache is frequently very intense in character. At the beginning of the inflammation there may be simply heat, fulness, and pressure. Afterwards, however, it goes on to sharp penetrating pain in the ear, which generally extends to the neighbourhood, to the temple above, towards the occiput behind, or to the forehead in front. It may be accompanied by throbbing or hammering in the ear, aggravated at night. In the purulent form, the pain often ceases with rupture of the membrane, and the appearance of discharge from the ear. In some cases, however, the pain continues after rupture, or returns after a period of intermission.

The external auditory canal is another common source of pain, especially when it is the seat of furuncular or circumscribed inflammation. The pain in this case is usually aggravated by moving the auricle, pressing the tragus, or by mastication. Less frequently there is pain in the external canal from eczematous inflammation, from the pressure of cerumen in the osseous portion of the canal, from the presence of fungi, from exostosis, and from caries or necrosis of the osseous walls of the canal. In eczema of the external canal the sensation is more that of troublesome itchiness.

Mastoid inflammations are important sources of pain. In mastoid periostitis there is usually œdema or abscess over the mastoid area, with jutting outwards of the auricle, and great tenderness on pressure. In purulent collection in the mastoid cells, there may be little or no œdema over the mastoid, but only an appearance of bulging of the bone itself, with pain on pressure, especially over the antrum. There is sometimes in such cases, however, very little pain apart from pressure.

In chronic purulent affections of the middle ear, while in most cases no pain may be experienced for years, there may arise at any time severe pain from an acute inflammatory attack, from pressure of retained discharge or cholesteatomatous matter, from caries or necrosis, or from furuncular inflammation in the canal. Intense

pain in an ear affected with chronic purulent disease, extending to the side or back of the head, may be the first symptom of a cerebral abscess or other intracranial complication.

Slighter and more intermittent pain may be complained of in connection with simple exudative catarrh of the middle ear or with interstitial or sclerotic processes. If great pain is experienced in such conditions, it generally means an intercurrent acute inflammation.

Non-inflammatory Pain. The second or non-inflammatory variety of pain—frequently termed otalgia—is often connected with dental caries. It may be associated with pains in the vicinity—in the neck, temple, or cheek. It is sometimes a manifestation of a neuralgic condition due to anæmia or other constitutional defect. Intense pain is also sometimes experienced in the ear during the course of tonsillitis, without any signs of inflammation in the ear. Rheumatic pain in the articulation of the lower jaw, felt during movement or pressure, is sometimes thought by patients to be due to ear disease. A feeling in the ear, as if a plug of cotton were in it, sometimes complained of by persons with good hearing, has evidently a nervous origin.

It is important, as a guide to treatment, to distinguish between the inflammatory and the non-inflammatory forms of pain. Objective examination is of course the only reliable means of doing so, and should never be omitted in such cases. We usually find in the inflammatory variety more or less defect in the hearing as well as subjective sounds in the ear; and it is often distinctive of the non-inflammatory pain that it has been experienced for a long period, even for months.

It is well always to inquire whether the patient has been liable to earaches in childhood, or later on, as these may indicate past inflammatory attacks.

V. GIDDINESS AND STAGGERING.

Since Ménière's classical paper on "Aural Giddiness," in the *Gazette Medicale de Paris* for 9th February, 1861, the profession has become gradually impressed with the importance of giddiness as a symptom of ear disease; and most practitioners now think of the ear when a case of giddiness presents itself.

Frequency of Ear Giddiness. As a sign of ear disease it occurs in all degrees of intensity from that of a slight and temporary lightness in the head to so violent a disturbance of the equilibrium as to necessitate the recumbent posture. In a marked form it is far from being rare, while in a comparatively mild degree it is a very common concomitant of ear disease. In 1276 consecutive

cases occurring in the author's hospital practice, there were 73 cases, or 5½ per cent. of marked giddiness, and 237 cases, or 18 per cent., in which there was slighter or occasional giddiness. In 1025 consecutive cases, occurring in his private practice, there were 63 cases, or 6 per cent., in which giddiness was a distinct feature.

Various Forms of Ear Giddiness. Ménière's discovery naturally stimulated much investigation, with the result not only of still more widely connecting the symptom of giddiness with disease in the ear, but also at the same time of modifying some of his views. While he believed that these symptoms had always, as their basis, a lesion, usually haemorrhagic, in the labyrinth, further investigation and experience have modified and enlarged this view, and it is now well known that giddiness may be associated with almost any form of ear disease. In the light of the fuller experience of recent years, aural giddiness may now be conveniently described as manifesting itself in four distinct forms: (1) The typical form or true Ménière's disease (sometimes termed apoplectiform deafness), due to the presence of exudation in the labyrinth. In a person with previously normal hearing, the four great symptoms, namely—sickness and vomiting, giddiness and staggering, subjective sounds in the ear, and deafness, occur as a sudden seizure. In this class entire disappearance of all the symptoms is rare. (2) Another form is due to pressure upon the walls of the middle ear of air, liquid, or inflammatory products. Here the symptoms are sometimes less severe in character—the sickness and vomiting being occasionally absent while the vertigo is in most cases preceded by other symptoms of auditory disturbance. Disappearance of the symptoms, however, is usually effected by suitable treatment. (3) The giddiness may be due to pressure upon the walls of the external auditory canal or outer surface of the tympanic membrane, especially by cerumineous masses. Here also it is usually preceded by disturbance of the hearing, and entire recovery is often brought about by treatment. (4) In the fourth class of cases, the giddiness is due to chronic processes in the middle ear, leading to pressure upon the labyrinth at the fenestral openings, or to vaso-motor disturbance in the labyrinth. The vertigo of this class is that usually termed by writers, *vertigo ab aure læsa*, and may occur in almost any affection of the ear: but it is most frequent in the course of a chronic inflammatory affection of the middle ear. The giddiness is generally preceded, accompanied, and followed by subjective sounds and deafness; and is frequently without nausea or vomiting. Recurrences of the giddiness are common from time to time. In most cases it eventually disappears: but the deafness and the noises in the ear remain permanently.

Relation of Ear Giddiness to Intra-cranial Disease. It is necessary to remember that in the course of chronic purulent disease of the middle ear, and also, but much more rarely, in acute purulent disease, giddiness may be due to extension of the disease to the brain or other parts of the intra-cranial cavity. In such a case, however, the giddiness is associated with other grave symptoms which point to involvement of structures more central than the organ of hearing. In this way meningitis, septic-thrombosis of the sigmoid sinus, cerebral abscess, or cerebellar abscess may be associated with more or less disturbance of the equilibrium. It is also to be remembered, however, that grave disease of the cerebellum, such as a tumour, sometimes exists in a person who may be at the same time afflicted with an ear disease, although no connection may exist between the two. In this way there may be great disturbance of equilibrium, which, at first sight, is regarded as of aural origin; but subsequent events show that the disease causing the disturbance of equilibrium is entirely in the cerebellum, having possibly no connection with the ear. It should never be forgotten that *marked giddiness, sickness, and vomiting may exist in connection with purulent disease of the ear, which has not extended beyond the cavities of the middle ear.* There is no doubt that practitioners sometimes form an unnecessarily gloomy prognosis of such cases, concluding, owing to the presence of these symptoms, that extension of the mischief has taken place to the interior of the cranium.

VI. SICKNESS AND VOMITING—FAINTING—COLD SWEATS.

These symptoms, when arising from ear disease, are usually associated with giddiness and staggering (see p. 45). They usually begin soon after the disturbance of equilibrium, and are probably due to reflex action through the vagus nerve. They naturally suggest the possibility of brain mischief. On the other hand, both patients and practitioners frequently regard such attacks as purely bilious in their nature. The sickness and vomiting rarely last beyond a day or two.

Pallor of the face and cold sweats, with, in some cases, fainting, are often features of an attack of Ménière's disease. When a patient is seized with such symptoms as giddiness and staggering with sickness and vomiting, the organ of hearing should be carefully examined. It is also to be remembered that sickness and vomiting in connection with ear disease may be due to the extension of purulent ear disease to the intra-cranial cavity.

VII. ABNORMAL SENSATIONS IN THE HEAD.

Headache is not unfrequently experienced in ear disease. In acute inflammatory affections of the middle ear or of the external auditory canal, shooting pains may be complained of in the temple and occiput. Such pains are often regarded as neuralgic in nature, and, in the absence of objective examination, the condition of the ear may be overlooked. In chronic non-exudative catarrh of the middle ear, similar pains may be experienced in the branches of the fifth nerve, originating in irritation of the mucous lining of the middle ear. In chronic purulent inflammation of the middle ear, heavy dull pain in the head is sometimes complained of, particularly by anæmic and weakly persons. In this affection, however, when pain in the head becomes a sudden, severe, and continuous symptom, and especially when situated above or behind the affected ear, and aggravated by pressure or palpation, we should think of the possibility of an intra-cranial complication, such as abscess, or meningitis, or thrombosis of the lateral sinus. Suppuration in the mastoid cells, or mastoid periostitis, is likely to be attended by pain in the neighbouring regions of the head. Frontal headache may be complained of in connection with ear disease due to a co-existing nasal catarrh which has involved the frontal sinus. A benumbed sensation over the corresponding side of the head is often spoken of by patients suffering from acute catarrhal conditions of the middle ear.

Some patients, especially those who are neurotic, complain very much of a sense of pressure on the top of the head, especially in connection with chronic non-exudative catarrh.

VIII. DISTURBANCE OF THE SENSORIUM.

Nervous Phenomena. A feeling of heaviness, confusion, or depression is often mentioned by patients suffering from affections of the middle ear, and they may also assert that an amount of mental work, which they could at one time perform with ease, has now become impossible. These symptoms probably occur in persons whose nerve force or resisting power is either naturally weak or has been impaired by causes acting on the system independently of ear disease. The distracting influences of noises in the ear, which frequently attend these affections, may have something to do with the causation of nervous phenomena. A special form of diminished power of mental application, termed by Professor Guye "aprosexia," is frequently noticed in children affected with post-nasal growths and exudative catarrh of the middle ear.

Intra-cranial Symptoms. The more serious symptoms indicative of intra-cranial disease, such as stupor, delirium, convulsions, coma,

and paralysis, may be met with in connection with the intra-cranial complications of purulent middle ear disease. It is to be noted, however, that acute affections of the middle ear may, in infants and very young children, be attended by such symptoms without meningitis or other intra-cranial disease. Only by very careful examination of the ear in these cases will the aural origin of the symptoms be discovered.

IX. PYREXIAL SYMPTOMS.

Increase of temperature and other symptoms of febrile disturbance occur in most cases of acute purulent inflammation of the middle ear, and, less frequently, in non-purulent inflammation. Acute mastoid inflammations are also generally attended by rise of temperature. In certain cases these symptoms are very marked, and a temperature of 102° F. is not uncommon. Even in the acute inflammations of the external canal, some elevation of temperature is usual. When meningitis or thrombosis of the lateral sinus occurs, the feverish disturbance becomes, of course, a very notable feature of the case.

X. DISTURBANCE OF SIGHT, SMELL, AND TASTE.

Disturbance of vision is rarely *caused* by an ear affection; but it may be *associated* with hereditary syphilitic disease of the labyrinth, in the form of iritis, or keratitis, or both. Of course, in the intra-cranial complications of purulent ear disease, the optic nerve may show on examination the presence of neuritis. Disturbance of the ocular muscles is a well-known symptom of intra-cranial mischief.

The sense of smell, when affected in connection with an ear disease, is rather due to a morbid state of the nasal mucous membrane, which may have been the cause of the ear disease.

The sense of taste may be impaired, especially on one side of the tongue, from a purulent disease of the ear on the same side. This is due to implication of the chorda tympani nerve, either as it passes through the tympanum or before it branches off from the facial nerve. A disagreeable taste in the mouth is, in some cases, due to the escape of pus from the Eustachian tube to the throat and back of the mouth.

XI. NASAL AND PHARYNGEAL SYMPTOMS.

Nasal and pharyngeal symptoms frequently co-exist with ear disease. Persons suffering from middle ear affections often have a sense of nasal obstruction, and are unable to breathe freely through the

nasal passages, especially when sleeping. They complain less frequently of sneezing, which is due to the catarrhal condition of the nose associated with the ear affection. Nasal voice is sometimes a marked feature in children suffering from catarrhal deafness, the nasal tone being due to a concomitant affection of the nose. The frequent desire to clear out the throat, "hawking," is often associated with catarrhal conditions of the middle ear, due to post-nasal catarrh, which may be the root of the ear affection. For further information regarding nasal and throat symptoms, see the special chapter on "Affections of the Nose and Throat."

CHAPTER III.

CAUSES OF EAR DISEASE.

Although, in the description of the individual diseases of the ear, their causation will in each case receive attention, it may be useful to review in a general way the various predisposing and exciting causes which are apt to give rise to morbid conditions of the organ.

I. CAUSES ACTING THROUGH THE EXTERNAL AUDITORY CANAL.

Action of Cold. We do not here refer to the action of cold in producing, primarily, catarrh of the nasal and pharyngeal spaces, and, secondarily, catarrh or inflammation of the middle ear, but to the action of cold impressions directly upon the ear. A very large number of ear diseases originate in this way. The ear is remarkably intolerant of cold, which may act upon it in various ways, such as by the rushing of cold water into the ear while the person is diving; or by the trickling of drops of cold water into the ear during washing, a shower bath, or the application of ice to the head: or by exposure to cold wind, especially if accompanied by rain, sleet, or snow. Exposure to these causes is especially liable to excite an ear affection, if a marked predisposition to such exists in the individual, or if a chronic disease is already present, especially if attended by a perforation.

Cutaneous Extension. Disease may also affect the ear through the continuity of the interior of the ear with the cutaneous surface of the body. For example, the exanthemata sometimes affect the ear through the medium of the cutaneous lining of the external auditory canal. Erythema, erysipelas, or eczema, when affecting the head, may extend to the auricle and external auditory canal.

Mischievous Interference. Excess of ear wax, furunculi, and acute diffuse inflammation of the external auditory canal are not unfrequently the results of irritating the skin of the canal by efforts to relieve itchiness or remove wax. The point of a pen, a tooth-pick, a knitting or hair-pin, a small twig, etc., are used for

such purposes, and irritate the delicate cutaneous lining. It occasionally happens that the person's elbow receives a sudden push, which thrusts the hard pointed object inwards, penetrating the tympanic membrane. Efforts to clean the interior of the ear by the use of so-called "aurilaves," or with the corner of a towel, not unfrequently lead to accumulation of the ear wax in the deep parts of the canal. Needless and unskilful syringing of the ear, and the pouring into the ear of irritating or even caustic liquids, are sometimes responsible for acute inflammation of the canal, the tympanic membrane, or the middle ear. Even the indiscriminate pouring of bland oil into the ear may prove injurious, owing to its becoming rancid after being in the warm ear for a few days, when it may act as an irritant, or favour the formation of fungi. Boring the lobule of the ear and the irritation caused by ear ornaments may give rise to disease, especially to eczema, hypertrophy, or cleft lobule.

Blows upon the Ear, boxing or pulling the ears, or striking the surface of water with the side of the head, as in diving, may, by the sudden and great compression of air in the external auditory canal, rupture the tympanic membrane, or even some of the tympanic structures, giving rise, it may be, to acute purulent inflammation of the middle ear. If the auricle has been previously weakened by disease, a severe blow may be followed by hæmatoma auris. A foreign body in the external auditory canal, or *the efforts to remove the same*, especially when it becomes firmly impacted, may cause perforation of the membrane and purulent inflammation of the middle ear. The same results are likely to follow the entrance of boiling water, molten metal, caustic substances, etc., into the ear.

Efforts at Treatment, especially when of an injudicious character, may produce serious mischief. Improper attempts to remove a foreign body, or violent and unnecessary syringing, may bring about acute inflammation of the canal and tympanic membrane. Certain methods of treatment, which are usually safe and beneficial, occasionally prove mischievous. Thus paracentesis of the tympanic membrane, perfectly safe in the vast majority of cases, occasionally excites acute purulent inflammation of the middle ear.

Very Loud Noises, especially if sudden and unexpected, as when a cannon is fired close to the ear, or the piercing shriek of a railway whistle is suddenly heard, not unfrequently originate disease of the ear, and the former may even rupture the tympanic membrane. Constant and loud noises have also frequently an injurious effect on the ears, and hence it is found that a large proportion of men, who are exposed from the nature of their work to such noises, ultimately become deaf.

II. CAUSES ACTING THROUGH THE EUSTACHIAN TUBE.

There is probably no greater predisposing or exciting cause (in producing or maintaining ear disease), than the presence of disease in the nasal and pharyngeal mucous membrane; and a special chapter is devoted to this subject.

The chief morbid conditions which exercise an influence upon the middle ear are:

(*a*) Acute rhinitis (acute cold in head).
(*b*) Chronic rhinitis (chronic cold in head).
(*c*) Adenoid vegetations in the naso-pharynx.
(*d*) Acute and chronic pharyngitis.

Exanthemata. The rhinitis associated with the exanthematous diseases, especially scarlet fever and measles, has often a virulent effect upon the middle ear. Any one of the diseases of the middle ear may thus have its origin in scarlet fever or measles, but the purulent inflammations arise in this way more frequently than do the simple catarrhs. Probably the most obstinate purulent diseases of the ear, and those which are attended by greatest destruction of the tympanic membrane, arise from scarlet fever. Diphtheria may affect the ear by extending up the Eustachian tube from the pharynx; and, when it occurs in conjunction with scarlet fever, most serious purulent disease may be set up. Diphtheria may also damage the ear by causing paralysis of the muscles of the palate and Eustachian tube.

Syphilis. Syphilitic cicatrices, by closing the mouth of the Eustachian tube, or by producing adhesions of the soft palate or perforation of the palate, may lead to disease in the middle ear.

Pulmonary Affections. Pneumonia, bronchitis, influenza, whooping-cough, phthisis pulmonalis, etc., may excite morbid conditions of the middle ear, by simple continuity of the mucous membrane, by the strong expiratory efforts of coughing unduly condensing the air in the middle ear, or by the invasion of specific microbes.

The Nasal Douche and other forms of nasal treatment are also in some cases responsible for setting up middle ear disease. The entrance of liquid into the middle ear through the Eustachian tube, during the use of the nasal douche or syringe, is no doubt a common occurrence; but this accident is fortunately by no means always followed by inflammatory mischief. Patients, especially children, frequently mention that they experience pain in the ear during the act of syringing, although no harm results. On the other hand, injury to the ear may ensue, such as purulent disease with all its possible consequences, or simple catarrh with temporary or permanent injury to the hearing. While many of the cases of purulent middle

ear disease excited in this way have been mild and short in duration, instances are, in the knowledge of the author, not very uncommon in which the disease has assumed a persistent, and even serious, character. The application to the nasal mucous membrane of the galvanic cautery or chromic acid, and operative treatment are sometimes responsible for the production of ear disease.

Abuse of Inflation. The abuse of the various methods of inflating the middle ear, especially Valsalva's method, may injure the tympanic structures by producing an over-flaccid state of the membrane. Rupture of the tympanic membrane, however, is probably never caused by inflation of the middle ear, unless the membrane has been previously weakened by disease.

These various conditions influence the middle ear through the medium of the Eustachian tube in the following ways:

Eustachian Closure. By closing the mouth of the Eustachian tube, through extension of congestion, swelling, and hypersecretion in the naso-pharynx to the mucous lining of the cartilaginous part of the tube, or by the encroachment upon its mouth of swollen, thickened, or hypertrophied tissue or adenoid growths; in either case bringing about mechanical closure, and the rarefaction of the air in the middle ear. Enlarged tonsils pressing the soft palate upwards upon the tube, and adenoid vegetations overlapping the mouth of the tube, are examples of such mechanical closure.

Inflammatory Extension and Microbic Invasion. By further extension of the inflammatory process to the mucous lining of the tympanum, and perhaps also to the mastoid cells, there may be produced, in the slight forms, catarrh, and in the more severe forms, simple or purulent inflammations of the middle ear. Mucus, pus, or blood forced from the naso-pharynx into the middle ear, when accompanied by pathogenic organisms such as those peculiar to ozena, diphtheria, scarlet fever, and certain forms of nasal catarrh, must prove sources of mischief.

The Eustachian Muscles. The thickened (hypertrophied), or atrophied mucous membrane of the soft palate may interfere with the contraction of the tensor palati and levator palati muscles, which are intimately connected with the mucous membrane covering them. The thickened mucous membrane (in the soft palate it may be three or four times thicker than normal) will impede muscular contraction, and bring about a disproportion between the resistance and the moving power. This impairs the muscular mechanism by which the walls of the membrano cartilaginous part of the tube are in turn separated and approximated. Paresis of these muscles may also result from diphtheria.

Ærial Contents of the Middle Ear. Through interference with nasal breathing the ear is deprived of a proper supply of pure air. When the nasal passages are markedly obstructed, rarefaction of the air in the naso-pharynx is produced by every act of swallowing, just as in Toynbee's experiment. This naturally leads to rarefaction of the air in the tympanic cavity through the aerial medium of the Eustachian tube. On the other hand, under the influence of vehement expiratory acts, such as coughing, blowing the nose, sneezing, etc., the air, unable to find its way through the nasal passages, may pass through the Eustachian tube with damaging effect upon the middle ear, through the sudden abnormal condensation of the air within it.

Reflex Effects. Probably certain forms of tinnitus aurium are due to the irritation caused by the pressure of the thickened mucous membrane upon the nerves, especially upon the branches of the trigeminus in the naso-pharynx.

III. INTRA-CRANIAL DISEASE AND CRANIAL INJURIES.

Intra-cranial Diseases. Morbid intra-cranial conditions may injuriously affect the auditory nerve or labyrinth. The internal auditory artery may be narrowed or closed from some cause, leading to anæmia of the labyrinth, or there may be aneurism of this vessel. Atheroma in the vessels of the brain is likely to be associated with the same condition of the vessels of the labyrinth, leading, it may be, to hæmorrhage into the latter. Obstruction to the discharge of the venous blood from the labyrinth into the sinuses of the brain may lead to passive congestion. Apoplectic clots, inflammation of the brain or meninges, tumours, abscesses, etc., may damage the root, stem, or expansion of the auditory nerve. Cerebro-spinal meningitis is responsible for many cases of deaf-mutism. Through the aqueduct of the vestibule or cochlea diseased changes in the arachnoid space are in some cases propagated to the interior of the labyrinth.

Blows upon the Head. Violent blows or falls upon the head may fracture some part of the osseous walls of the ear and rupture the tympanic membrane and other soft parts, causing effusion of blood into the middle ear or labyrinth, and perhaps injury to the auditory or facial nerves, followed usually by purulent inflammation of the middle ear. Blows on the head, however, not unfrequently produce permanent and total deafness with great subjective sounds, without causing any rupture of the middle ear structures or other appearances of injury.

IV. GENERAL DISEASES AND MORBID CHANGES INVOLVING THE CIRCULATION.

The strumous, tubercular, and syphilitic cachexiæ not only powerfully predispose to diseases of the ear, but they also engraft upon these diseases a specially unfavourable tendency.

In the Strumous Constitution acute inflammation of the middle ear is very apt to take a suppurative form, and to become chronic, persistent, and be attended by serious complication. Again, mucous catarrh of the middle ear is much more obstinate in the strumous child: while dry adhesive processes, when they do affect children, which is rare as compared with their frequency in the adult, usually occur in those of strumous constitutions.

In Tubercular Patients purulent forms of ear disease are not only common, but also attended by destructive softening of the tympanic membrane. In both scrofulous and tubercular persons chronic adhesive catarrh of the middle ear is more apt to take an unfavour-

able course than in those of healthy constitution. The tubercle bacillus is sometimes found in purulent middle ear diseases, but there is reason to believe that many cases are really tubercular in which no bacilli can be found. No doubt many of the cases of so-called caries of the mastoid process, especially in children who have at the same time enlarged lymphatic glands in the neck, are really tubercular disease of the mastoid and petrous portions of the temporal bone. In ten such cases Dr. Milligan of Manchester inoculated the purulent material into guinea pigs, with the result of producing marked tubercular disease in eight of these.

Syphilis may affect the organ of hearing in several ways. Condylomata, or ulceration in the cutaneous lining of the ear, may be due to it; or, in the stage of secondary symptoms, mucous catarrh of the middle ear may be excited by simple extension of the throat affection to the middle ear. A form of chronic catarrh is met with, involving the middle ear and labyrinth, and associated with rapid and serious loss of hearing. Great aggravation of the deafness in chronic catarrh of the middle ear is often seen as a result of the syphilitic virus; and sudden and serious loss of hearing in one ear, or, less frequently, in both ears, with subjective sounds and vertigo, due to some form of effusion into the labyrinth, sometimes takes place as the result of syphilis. Labyrinthine disease, coming on gradually or suddenly, leading to serious or total loss of hearing, preceded by keratitis or iritis, and often associated with Hutchinson's teeth, is not unfrequently met with in children suffering from hereditary syphilis.

Exanthematous and Zymotic Diseases. We have referred to the influence upon the organ of hearing, through mere continuity of skin and mucous membrane, of the exanthematous diseases, especially of scarlet fever and measles; but these diseases may also cause changes in the ear, especially in the labyrinth, through the circulation; causing marked and permanent defect of hearing. The other zymotic diseases not unfrequently induce mischief in the ear. During *typhus* and *typhoid* fever, temporary deafness and tinnitus are often observed, and are probably in most cases due to hyperæmia of the labyrinth; but permanent changes in the ear may also originate in these affections. The aural disturbance sometimes found in those who have suffered from intermittent fever is probably due rather to the effects of quinine than to the disease itself. In the recent epidemics of *Influenza* many cases of acute purulent inflammation of the middle ear, characterized by an unusually great tendency to mastoid suppuration, have been observed and reported upon by various authorities. Other forms of ear disease, presenting peculiarly severe and obstinate features, have been observed in connection with epidemic influenza.

Bright's disease, acute and chronic rheumatism, gout, anæmia, marasmus, are each not unfrequently associated with ear disease, but the exact nature of the causative relation is not clear. An attack of *mumps* is sometimes attended by permanent and total deafness in one or in both ears, from some as yet unknown change in the labyrinth. In *leukæmia*, hæmorrhage may take place into the cavities of the labyrinth. *Hysteria, pregnancy*, and the *period of lactation* are occasionally associated with disturbance of the hearing, or with aggravation of ear disease which has previously existed. Deafness is also sometimes observed during *puerperal fever*.

Organic disease of the *heart, lungs*, or *large vessels*, by causing stasis of the venous circulation in the head, or by producing undue arterial tension, may lead to hyperæmia of the mucous membrane of the nose, throat, and ear, passing, it may be, into distinct tissue changes.

Medicinal Substances. Certain medicinal substances, notably quinine, salicin, opium, and alcohol, when taken into the circulation, may induce disturbance in the organ of hearing, especially hyperæmia of the inner ear, producing deafness or some form of tinnitus. They have a more injurious effect if disease already exists in the ear, when even small doses may distinctly aggravate the aural symptoms, and the aggravation is undoubtedly in some cases permanent.

V. REFLEX CAUSES.

Morbid impressions are sometimes transmitted to the ear in a reflex way through the vaso-motor nerves, from various parts of the body. The effect of cold feet, in exciting inflammatory affections of the middle ear, is an example of this form of reflex influence. But probably the most marked instance is the production of inflammatory or neuralgic affections in the ear by the process of teething in the child, or by caries of the teeth in the adult. The connection of the dental nerves with the middle and external ear, through the otic and Meckel's ganglia, is probably the path by which the irritation is transmitted from the teeth to the ear. Sympathetic hyperæmia of the ear probably also arises from reflex sympathy with the digestive organs and, in the female, with disturbances of menstruation and the menopause.

VI. MICRO-ORGANISMS AS CAUSES OF EAR DISEASE.

In the production or maintenance of certain forms of ear disease, micro-organisms play an important part.

Favourable Conditions in the Ear. When we consider the structure of the ear, its numerous air-filled spaces, warm, dark, and moist,

and the tendency to the accumulation of inflammatory and other debris; when, further, we remember its communication with the nose, throat, and outer air, it is not surprising that it should be the seat of bacterial activity.

The following are the chief organisms associated with, if not the actual cause of, disease in the ear.

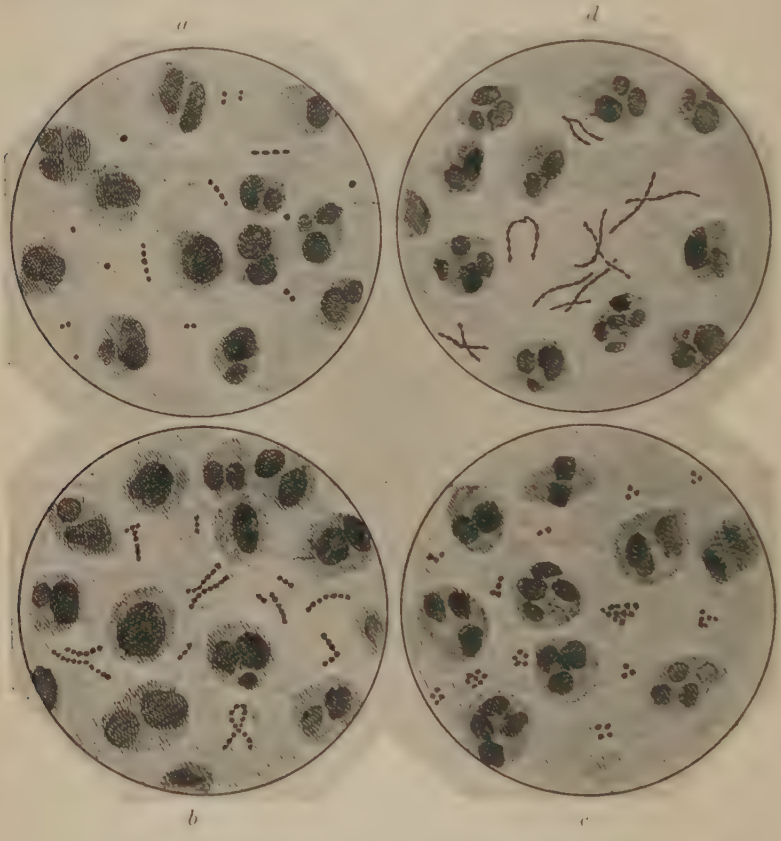

FIG. 33.—Micro-organisms found in purulent discharge from the ear. *a*, Diplococcus from a case of acute purulent inflammation of middle ear with nipple-shaped perforation, after influenza; *b*, streptococcus pyogenes from case of chronic purulent middle ear disease; *c*, staphylococcus pyogenes aureus from a furunculus in the external meatus; *d*, tubercle bacillus from case of chronic purulent middle ear disease in a child.

In the External Meatus certain inflammatory conditions are associated with fungi belonging to the species of aspergillus. It is to be noted, however, that these fungi have been known to exist in an external auditory canal without exciting mischief of any kind. There is reason to believe that furuncular inflammation is excited by a special micrococcus, which finds a habitat in the hair follicles, namely, according to Kirchner, the staphylococcus pyogenes (aureus and albus).

In the Middle Ear many pathogenic organisms have been found in connection with inflammatory processes. The most important are the following: (1) The streptococcus pyogenes (Fig. 33, *b*), which seems to be most frequently associated with chronic purulent disease and with cranial suppurations attending it. This is one of the most virulent micro-organisms found in the ear. (2) Fränkel's pneumococcus or diplococcus (Fig. 33, *a*). (3) The pneumo-bacillus of Friedländer. These two latter organisms seem to be most frequently associated with the acute forms of purulent middle ear disease, and are both encapsuled when found in the body. (4) The staphylococcus pyogenes (Fig. 33, *c*), albus and aureus, are also frequently found in connection with purulent processes in the middle ear, as well as with boils in the external canal. (5) The tubercle bacillus (Fig. 33, *d*) is found in certain purulent middle ear diseases, being often associated also with extensive tubercular infiltration of the mastoid and petrous portions of the temporal bone. (6) Löffler's bacillus seems to migrate into the middle ear from diphtheritic conditions of the naso-pharynx. It has been found even in the labyrinth and petrous bone. (7) The micrococcus of ozæna may invade the middle ear and excite purulent disease. (8) The schizophytes associated with malarial conditions, with particular seasons of the year, with peculiarities in the rainfall, or with emanations from drains, etc., are supposed to be accountable for certain forms of otitis media.

In the Labyrinth, the diphtheritic bacillus, the streptococcus, the staphylococcus, and the diplococcus are sometimes found.

Effects of Micro-organisms. No doubt, in regard to all these organisms, their effects on the ear are modified by pathologico-anatomical conditions, the resisting power of the tissues, the nature of the pabulum, and the presence or absence of other irritating causes, such as cold or injury. In certain circumstances, these organisms may exist in the ear unattended by any morbid process. They sometimes migrate into the pharyngeal spaces, and even find their way into the stomach and lungs. In order to determine the nature of the primary microbe, we should, if possible, examine the secretion after paracentesis of the tympanum or immediately after perforation of the membrane. Subsequently microbes may be found having no connection with the original source of the mischief.

VII. PREDISPOSING CONDITIONS.

Heredity. Hereditary tendency is a strong factor in the causation of almost all forms of ear disease, but more especially of those morbid changes which are usually designated chronic adhesive catarrh

of the middle ear. We sometimes find the hereditary disposition extremely marked, almost every member of a family having some form of disease of the ear. It is to be noted, however, that the offspring may not be affected with the same disease as the parent. For example, the father may have chronic adhesive catarrh, while his children may be liable to purulent inflammation of the middle ear. We may find also that the hereditary tendency is not direct, that, while the father and grandfather have enjoyed a healthy state of the organ, the uncle or grand-uncle may have had ear disease. Politzer believes that the hereditary influence is stronger in the second generation than in the immediate offspring. It must be remembered, however, that these diseases are very common, and that, although we may frequently discover by diligent inquiry that some relative has dulness of hearing or an ear discharge, we are not justified in all such cases in concluding that real hereditary tendency exists. It is asserted by some that the hereditary tendency consists in a peculiar formation of certain parts of the middle ear, such as a narrow or small formation of the recesses leading to the fenestral membranes, favouring the detention and organization of catarrhal products. Probably the hereditary peculiarity is rather what may be called the "catarrhal tendency," which almost always manifests itself at the same time in a special liability to nasal and pharyngeal catarrhs.

Age. The peculiarities attending different ages of life are important factors in the production of ear disease. In childhood there is a marked liability to exudative diseases of the middle ear, especially of a purulent character, as compared with persons of more advanced years. While this frequency is to a great extent due to the prevalence of exanthematous diseases at that time of life, it is also connected with certain peculiarities of structure existing in childhood, viz., the small size of the naso-pharyngeal space, the thickness of the mucous membrane of the Eustachian tube, and the narrowness of the pharyngeal mouth of the tube. The frequency of adenoid vegetations in childhood also markedly favours the production of ear disease. The rapid formation of mucous membrane in the tympanic cavity, which takes place soon after birth, probably induces congestive processes in the tympanum, and it has been shown that purulent collections are frequently found to exist in the middle ears of young infants. In middle and advanced life, on the other hand, chronic adhesive or dry catarrh of the middle ear is very much more frequent than in children. In old age the flaccid soft walls of the cartilaginous Eustachian tube, as well as the feeble state of the tube muscles, may probably cause disease by disturbing the ventilation of the middle ear.

Position in Life, Occupation, Habits, and Surroundings have great influence in the causation and continuance of ear disease. In the case of the poor, their greater exposure to all kinds of weather; their cold, damp, ill-ventilated dwellings; their deficient nourishment and scanty clothing, render them more liable to inflammatory affections of the ear, which in such persons are also likely to be more persistent. We note especially the effects of these evil influences in the children of the poor, suffering from chronic purulent inflammation of the middle ear. Workmen exposed to loud or sudden noises, such as boilermakers, riveters, or railway engine drivers, are particularly liable to labyrinthine mischief, from undue irritation of the auditory nerve. Those, again, who have to work in the midst of air loaded with dust or dirt, or who are employed in an office where the air is confined, close, and impure, are prone to ear affections. The immoderate use of alcohol and of tobacco may not only directly produce ear disease where the tendency to such exists; but, by bringing on a state of chronic catarrh of the pharyngeal mucous membrane, ear disease may be in that way indirectly caused. Mental worry also predisposes to ear trouble in certain constitutions.

Pre-existing Diseases in the Ear. The previous or present existence of disease in the ear may predispose to a return of the same or to other diseases. As in almost all catarrhal diseases, one attack is apt to establish a tendency to future attacks. Thus, a person who has had at any time catarrhal or inflammatory disease of the middle ear, is more liable to have this again. So the existence of a chronic disease of the ear, such as chronic adhesive catarrh, or chronic purulent inflammation, exposes the individual to acute catarrhal or inflammatory attacks. Then, again, disease in one part of the ear frequently leads to disease in another part. Congestive or inflammatory conditions of the middle ear are often attended by hyperæmia of the labyrinth, leading, it may be, to tissue changes. Chronic catarrhal or suppurative diseases of the middle ear are often followed in time by pathological changes in the labyrinth. Affections of the mastoid process are, in the great majority of cases, the result of pre-existing disease in the tympanic cavity. Again, furunculi, diffuse inflammation, or even hyperostosis of the external auditory canal, may arise from the irritating action of pus or other secretions upon the skin of the canal. Eczema of the auricle is also apt to excite a similar state of the canal, with thickening of the cutaneous lining.

Neglect of Treatment. We have to add neglect of proper treatment as an element in the perpetuation of certain diseases of the ear. From this cause acute diseases frequently lapse into chronic conditions. Thus mucous catarrh, or acute non-perforative inflam-

mation, may pass into the much less curable chronic adhesive catarrh. Probably, however, the disease which is most frequently due to neglect of treatment, is chronic purulent inflammation of the middle ear, owing to the fact that no efficient efforts are made to cleanse the interior of the ear, where, from the anatomical peculiarities of the part, there exists such a tendency to retention of secretion.

CHAPTER IV.

METHODS OF TREATMENT.

MANY of the methods of treatment or manipulations employed in diseases of the ear are useful in several affections, and, therefore, for the sake of convenience, and to avoid frequent repetition, we shall consider in this chapter the most important of them.

I. INFLATION OF THE MIDDLE EAR.

Of all the operative measures practised in diseases of the ear, this is probably the one most frequently employed. For a description of the various modes adopted the student is directed to page 12.

The therapeutic value of inflation is mainly based upon the mechanical effects of the compressed air on the walls and contents of the middle ear. Its effects on the walls are confined to the yielding parts, namely, the tympanic membrane, the membranous part of the Eustachian tube, the membrane of the fenestra rotunda, and the annular band of the fenestra ovalis.

Effects of Inflation on the Walls of the Middle Ear. In many pathological states the tympanic membrane and the ossicular chain are pushed unduly inwards, so that the base of the stapes presses abnormally upon the fluid of the labyrinth. The vibrating power of the membrane and ossicula is at the same time impaired by this increased tension. The mechanical effect produced by the pressure of the air upon the inner surface of the tympanic membrane during inflation, forces out the membrane and chain of bones, thus relieving the labyrinthine fluid, and helping to restore the proper tension. The action of the compressed air in the tympanic cavity will at the same time tend to break asunder adhesions or bands, if these have not become too much organized, and also help to overcome abnormal retraction of the tendon of the tensor tympani muscle. It is possible also that, through the mechanical effect of the pressure of air upon the fenestral membranes, if frequently repeated, any tendency to their becoming rigid may be successfully resisted. The stream of

compressed air, acting laterally on the Eustachian tube, will co-operate with the tube muscles in separating the outer or membranous wall from the inner or cartilaginous one, and thus open the canal, impermeability of which is generally the result of pathological changes in the mucous membrane, preventing the effective action of the muscles.

Effects on Secretion in the Middle Ear. The current of air has also an important effect upon fluid secretion in the middle ear. When the secretion is in the pharyngeal end of the Eustachian tube, it is usually forced by the air into the naso-pharynx. In the tympanic cavity the secretion is finely divided, and scattered in various directions. In this way its absorption by the lymphatics and blood-vessels is assisted, while secretion lying on those parts whose vibrating function is of great importance, such as the ossicular chain or fenestral structures, may be removed to other parts, where its effect on the hearing may be less injurious, such as, for instance, into the antrum mastoideum, or, if there is a perforation of the membrane, into the external auditory canal.

Value of Catheterization. Catheterization (Fig. 25) is most useful in chronic forms of middle ear disease, when a strong and somewhat prolonged current of air is required to overcome the resistance offered by adhesions. It is also to be preferred, when the disease is limited to one side, and it is undesirable that air should be forced into the normal ear. When liquids, vapours, solid bodies, etc., require to be introduced into the middle ear, the catheter is generally indispensable. In a few rare cases the use of Politzer's method is attended by such unpleasant consequences that we have to resort to the catheter. Since the introduction of Politzer's method of inflating the middle ear, however, catheterization has been much less employed than previously.

Value of Politzer's Method. Politzer's method (Fig. 27) possesses the following advantages. (1) It is of great value in the treatment of ear diseases in children, in whom the Eustachian catheter can rarely be used. (2) In acute catarrhal conditions of the nasal and pharyngeal mucous membrane, so often associated with catarrh of the ear, it has the advantage over the catheter of not irritating the inflamed mucous membrane. (3) When, in the adult, serious difficulties stand in the way of using the catheter, such as extreme nervousness or sensitiveness, a peculiar formation of the nasal passages, etc., this method is a useful substitute. (4) It requires no such special dexterity as catheterization, and it can not only be carried out by any practitioner, but with proper directions, and under sufficient precautions, it may be employed by the patient himself or by a friend in the intervals between the visits to the surgeon. (5) In certain conditions it is found that a better effect is

obtained by the sudden gust of air propelled into the middle ear by this method, than by the slower, more gradual current through the Eustachian catheter.

Value of Valsalva's Method. It is of most value in cases where the tympanic membrane is perforated. In these cases, when there is secretion in the middle ear, the patient is sometimes able to assist in the treatment by forcing the secretion from the tympanum into the external auditory canal. In the same class of cases solutions poured into the canal of the ear penetrate more effectually through a perforation into the middle ear immediately after air has been forced by this method through the fluid.

When the membrane is intact, the patient is either quite unable to inflate the middle ear, or, if able, he generally injures the ear by too frequent repetition. Temporary improvement of the hearing not unfrequently attends successful inflation by this method, and hence it is frequently practised by patients and recommended by surgeons. Such efforts, however, repeated by patients, perhaps many times daily, produce on each occasion a congestion of the tympanic vessels, which tends to aggravate the catarrh, for the relief of which they are used. Then, the more frequently it is performed the slighter and shorter in duration is the improvement of hearing —the case usually becoming worse and worse. Strong expiratory efforts produce hyperæmia of the vessels of the head, and stasis of its venous circulation, so that in persons with an unhealthy state of the vessels of the brain, the very frequent and vigorous performance of Valsalva's method is not free from danger. Persons have been known to fall unconscious to the ground when in the act of thus inflating the ear.

It is necessary, when the patient is recommended to try this method, that he be strictly cautioned against its too frequent use; and in elderly persons, especially if liable to giddiness, it should not be employed at all.

II. LOCAL ABSTRACTION OF BLOOD.

In the treatment of the acute inflammatory affections of the ear, local blood-letting is often of value. The blood is usually removed by leeches.

Application of Leeches. The proper situations for the application of leeches are in front of the tragus, behind the auricle, and over the stylo-mastoid foramen; depletion produces in these places the greatest effects on the ear. When the inflammation has its seat chiefly in the external auditory canal and tympanic membrane, the leeches should be applied over the tragus; when in the tympanum

or mastoid cells, they should be applied below and behind the auricle. The deep auricular artery, after supplying the tragus, passes in to supply the deep parts of the external auditory canal and the outer layer of the tympanic membrane, so that, in removing blood from the tragus, we are more likely to affect the circulation in the canal of the ear and in the tympanic membrane. The soft parts over the mastoid process and behind the lobule have their vascular supply from the stylo-mastoid artery, which provides also the chief arterial supply to the lining membrane of the tympanum and mastoid cells, where also arterial twigs inosculate with the small arteries of the labyrinth. Again, a communication exists between the veins over the mastoid process and the venous sinuses of the dura mater, through the diploetic and emissary veins which pierce the mastoid part of the temporal bone. Hence, by abstracting blood from the soft parts over the mastoid process, we may exert an influence upon the circulation, not merely of the tympanum and mastoid cells, but also of the labyrinth and dura mater.

Precautions in Using Leeches. In order to avoid any mistake, the precise spots to which the leeches are to be applied should be marked with ink. If, for example, a leech is applied over the parotid gland instead of over the tragus, there is not only a probability of irritation and swelling, but the therapeutic effect is unlikely to be attained. Before applying leeches the external orifice of the ear should be stopped with cotton wool, so as to prevent the entrance of a leech or of blood. After they have come off, the bleeding may be allowed to continue for ten or fifteen minutes. Instructions should be given as to the proper methods of stopping the bleeding, in case this should prove excessive. If there is a purulent discharge from the ear, the leech bites should be covered with skin plaster or other material so as to protect them from the effects of the irritating pus, which might excite inflammation, ulceration, or even erysipelas.

The artificial leech of Heurteloup, which consists of a scarificator and a suction pump, is sometimes used instead of leeches. The scarificator is a small circular knife, which, by pulling a string, is made to revolve rapidly. In this way a circular cut is made in the skin. The pump consists of a glass barrel with a cork piston, the rod of which is a metallic stem wrought into a screw. The suction is made by turning a handle at the outer end of the rod. Before the barrel is applied over the scarified part, the piston should be screwed completely down, while the edge of the barrel, which is to be applied to the skin, should be smeared with grease. By means of this instrument we are able to remove the blood quickly and to regulate the quantity.

III. SYRINGING THE EAR.

The ear syringe is frequently brought into requisition both for diagnosis and treatment. Before the surgeon syringes the ear, he must first ascertain by examination whether ceruminous, purulent, or other accumulations really exist. Injury is no doubt sometimes inflicted by the use of the syringe when there is nothing to remove.

Suitable Syringe. A piston syringe (Fig. 34) is generally the most efficient. If the surgeon has to deal with ceruminous collections or a foreign body, a syringe which contains four ounces is convenient, but, for other purposes, a two-ounce syringe is sufficient. One made of brass is perhaps to be preferred to vulcanite, as syringes made of the latter substance, although lighter and warmer, are liable to get

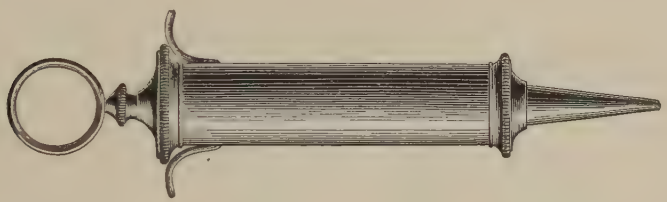

FIG. 34.—Brass ear syringe.

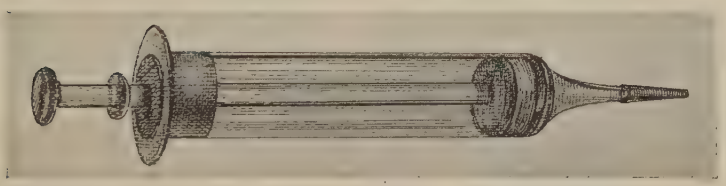

FIG. 35.—Glass ear syringe for use by patients.

out of order. *It should be furnished with a fixed ledge*, or other contrivance to prevent slipping of the index and middle fingers when the piston is being pressed down. The nozzle should not exceed an inch and a half in length, should be slender, and should not have a knob-shaped extremity. If the nozzle is too thick, or if it has a bulbous end, the canal of the ear is liable to be stopped up by it, and the injected fluid, having difficulty in passing out again, may produce dangerous pressure on the deep parts. The syringe put into the hands of patients should be smaller, as it is generally ordered for cleansing away purulent collections; one which holds an ounce of liquid is large enough. One made of strong glass (Fig. 35), furnished with a ledge for the fingers, is cheap and suitable. Whatever syringe is used by the patient, it should be provided with a

piece of fine, soft, india-rubber tubing, which covers the end of the nozzle and extends about a quarter of an inch beyond its point. This soft tubing may be introduced into the canal of the ear with greater safety by the patient or friend than a hard-pointed instrument. Ball syringes are useful when patients have to syringe their own ears, or for struggling children. For the latter the nozzle should be made of soft rubber and somewhat long (Fig. 36). The air should be well expressed from the ball, as bubbles of air mixed with the water are very unpleasant to the patient. A vessel (Fig. 37) of a suitable size and shape is required to receive the fluid as it issues from the ear. One made of vulcanite, black in colour so as to show the secretion, and shaped as in the woodcut, fits the irregular surface under the ear, and, if held close to the skin, will prevent

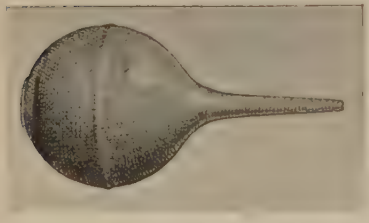

FIG. 36.—Ball ear syringe made of soft rubber.

FIG. 37.—Mode of syringing the ear.

the escaping fluid passing down the patient's neck. The comfort of the patient is not unworthy of our attention, and the drenching which patients sometimes undergo, not to mention the trickling of water down the neck and under the collar, must be avoided when syringing the ear.

Mode of Syringing (Fig. 37). The point of the nozzle of the syringe, or the india-rubber tubing, should be placed in contact with the roof of the canal, just within the external orifice. At the same time the auricle should be pulled upwards and backwards with the left hand, so as to remove the curve of the canal. When the object of syringing is to remove pus or other inflammatory products, the syringe should be used efficiently but gently, and with interruptions. A powerful stream of fluid propelled against the softened or perforated tympanic membrane may easily do injury. If the use of the syringe is entrusted to the patient or his friends, as in the treatment of chronic purulent disease of the middle ear, it is essential first to give careful

practical instructions. If this is not done, it will probably be found that the purulent secretion has not been removed from the deep part of the ear, the cleansing fluid having reached no further than the outer orifice of the canal. After syringing, the fluid which remains in the auditory canal should be allowed to drain out, and then the passage is to be dried with absorbent cotton fixed on a cotton-holder (Fig. 3). A plug of absorbent cotton should be worn in the meatus for twenty-four hours after syringing.

Untoward Effects of Syringing. In some persons syringing the ear, even when it is done with caution, excites giddiness, and more rarely, nausea and vomiting. These effects are more likely to be produced when the tympanic membrane is perforated, and especially when excessive force has been used, and when *cold* fluid is employed. Inflammation of the external auditory canal or the tympanic membrane may result from using cold water. The fluid may be simple water, as in the removal of ceruminous collections, or water medicated with some antiseptic substance, and it should always be pleasantly warm, say at a temperature of about 102° F.

Hinton's Mode of Syringing. Hinton recommended, for certain conditions of purulent disease of the ear, the use of a syringe whose nozzle hermetically closes the external auditory canal. The object was to inject liquid through a perforation in the tympanic membrane, and force the secretion contained in the cavity of the tympanum through the Eustachian tube into the pharynx. For the performance of this method of syringing it is essential that the Eustachian tube be freely permeable; and, even then, this method cannot be regarded as a perfectly safe one, because of the severe pressure to which the walls and contents of the tympanum are exposed. At all events only very moderate force should be employed in endeavouring to press the piston home; and if this is not sufficient to force the fluid into the pharynx, the method should be abandoned.

The Intra-tympanic or Attic Syringe. In some cases of purulent disease of the middle ear, especially in disease in the attic and antrum, it is desirable to inject fluid through a perforation in the membrana flaccida or in the osseous part of the external auditory canal. For this purpose we employ a fine cannula (Fig. 38), vulcanite or silver, attached at one end to an india-rubber tube connected with a ball or piston syringe. The other end of the cannula is bent, for introduction into the attic or other opening. The cannula used with the attic syringe has generally too narrow a lumen. A fairly good stream is required to dislodge the cholesteatomatous material in

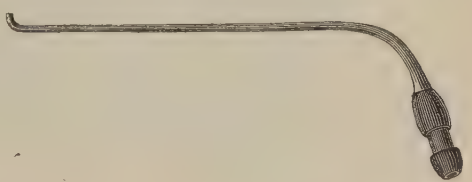

FIG. 38.—Cannula of attic syringe.

the attic, for which this method of syringing is often required. The attic syringe is often used after the operation of extracting the malleus and incus (see p. 101).

Mode of using the Attic Syringe. The solution, after being warmed, is drawn into the syringe or ball, the silver cannula of which is then carefully passed through the speculum into the inner end of the external auditory canal, and, with its bent point directed upwards, cautiously placed in the aperture in the membrane, which is usually in the membrana flaccida (Fig. 39). When the point of the cannula is in proper position, the outer end being held between the index and the middle fingers of the right hand, the ball is pressed with the thumb and index finger of the left hand (Fig. 40). At first only one or two syringefuls should be injected at a sitting; afterwards, however, a stronger stream and four or five syringefuls may be injected with advantage. In this way we often succeed in dislodging and bringing

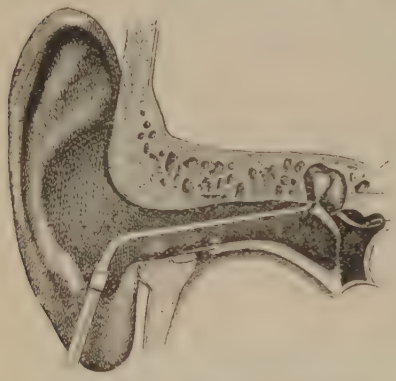

FIG. 39.—The introduction of the cannula of the attic syringe.

FIG. 40.—The use of the attic syringe.

away quantities of cheesy-looking or epidermic masses. Sometimes slight giddiness is complained of while the stream of fluid is passing upwards, but this is rarely severe, and usually after a few applications it is no longer experienced.

Syringing through the Eustachian Tube. The injection of fluid

is usually done with an ordinary syringe, through a catheter introduced in the usual way into the pharyngeal mouth of the Eustachian tube. This method must never be employed unless there is perforation of the tympanic membrane. As wide a catheter as possible should be selected, and its beak should be well inserted into the tube, and then held *in situ* as directed at p. 16, while the fluid is slowly injected into the mouth of the catheter. The injection is more effective if the patient breathe through the almost closed mouth. Generally a considerable portion of the fluid escapes into the nasal passages and pharynx, although there should pass through the Eustachian tube a quantity sufficient to drop, or even flow, out of the external auditory canal. The fluid is sometimes more effectually injected into the tympanic cavity through the *Paukenröhrchen* passed through a catheter as far as the tympanic orifice of the tube. This

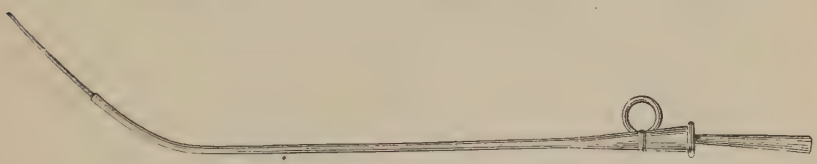

FIG. 41.—Fine tympanic tube introduced through catheter.

is a fine elastic tube, one end of which is widened into a funnel-shaped orifice, the other end having a small opening, sometimes placed sideways, to give passage to fluid. In introducing this instrument, a catheter is first passed in the usual way, and through this the tympanic tube is pushed into the Eustachian tube (Fig. 41). The point of the instrument is known to be in its proper position when, by means of a mark at the widened end, it is known to have passed from two and a half to three centimetres beyond the point of the catheter.

Gruber's Method. When *both* tympanic membranes are perforated, Gruber's method of washing out the middle ear through the Eustachian tube is sometimes employed. This consists in forcing fluid into the nasal passage by means of a syringe furnished with a nozzle, which fits tightly into one nostril, while the other nostril is closed with the fingers. The act of swallowing is performed by the patient, as in Politzer's method of inflation, while the piston of the syringe is pressed home. This method must never be employed if the perforation is limited to one ear, as the fluid forced into the sound ear may do harm.

IV. APPLICATION OF LIQUIDS OR VAPOURS TO THE MUCOUS MEMBRANE OF THE MIDDLE EAR.

The Application of Liquids to the Middle Ear. A small graduated syringe (Fig. 42) capable of containing ten minims of

fluid is employed. A wide catheter, having a long beak, should, if possible, be used; and the point of the beak is to be pressed well into the mouth of the Eustachian tube. The catheter, after being properly introduced, is held in position with the left hand; the syringe, which has been filled with the warmed liquid, is introduced into the outer opening of the catheter, and the fluid slowly and without much force injected into the catheter. The position of the patient's head should be such as to allow of the catheter being horizontal, so that the fluid may not flow out of it. By means of the air-bag a stream of air is then forced through the catheter, and the liquid is driven through the Eustachian tube and distributed as a spray upon the walls of the tympanic cavity. If the fluid be intended only for the Eustachian tube, the bag should be compressed with little force. If the head be inclined to the affected side and bent slightly forwards, the fluid may flow into the cartilaginous part of the Eustachian tube without the stream of air.

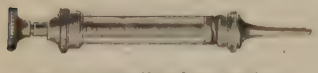

FIG. 42.—Small catheter syringe.

In forcing the liquid through the Eustachian tube a portion always flows back into the nasal passages and throat. This may be partly due to faulty catheterization, but is mainly owing to the partial hindrance presented by the swollen mucous membrane, especially at the *isthmus tubæ*. Coughing or retching may be excited, but soon passes off. When the fluid passes into the tympanic cavity, bubbling râles are heard during auscultation—one or two bubbles are often heard even after the inflation is over. A sensation of fulness and warmth is usually experienced in the ear, but pain is very rarely complained of, and inflammatory reaction almost never occurs, when suitable fluids are used.

Simple warm water may be employed for injection into the middle ear; but a variety of solutions are recommended. Probably the safest and most useful are 1 per cent. solutions of one or other of the following substances—bicarbonate of soda, chloride of ammonium, and iodide of potassium. Vaseline oil is also employed.

The Value of Liquid Applications. The solutions are chiefly employed in chronic adhesive catarrh of the middle ear; and the object aimed at is to irritate or stimulate the condensed, thickened, or rigid mucous membrane, so as to help to soften and render it more flexible, as well as to promote the absorption of the interstitial new-formation. It is right to state that some aural surgeons believe that the good effects obtained by injecting solutions into the middle ear are in reality due to the air pressure. The preponderance of evidence shows, however, that cases, which have not been benefited by the simple air douche, have afterwards improved by the use of injections.

Application of Vapours to the Middle Ear. Air impregnated with certain volatile substances is often introduced into the middle ear. A few drops of the volatile substance, such as turpentine or chloroform, may be poured into the catheter bag and allowed to volatilize, when the air containing the vapour is forced by compression of the air-bag into a catheter properly introduced into the Eustachian tube; or, what is probably still better, the mouth-piece of an air-bag which is firmly compressed with the hand is placed inside the mouth of a bottle partially filled with the volatile

FIG. 43.—Keen's valve and vapour box, used in Politzerization.

FIG. 45.—Godfrey's sal-ammoniac inhaler.

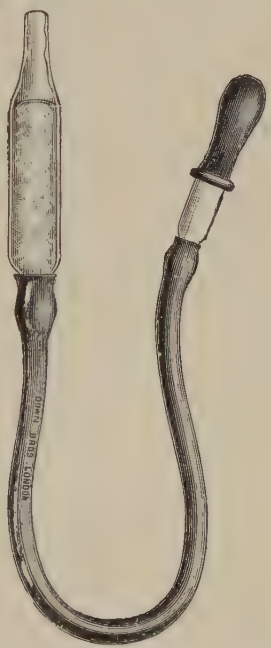

FIG. 44.—Dundas Grant's auto-inflator.

fluid, and the bag is then allowed to fill with the vapour in the upper part of the bottle. Inflation is then performed through the catheter in the ordinary way. In the same way, volatile substances may be applied during Politzerization; or there may be connected with the tube of the bag a box (Fig. 43) containing a piece of sponge or cotton wool, on which the volatile substance is placed, to impregnate the air as it passes through the box. Dundas Grant's auto-inflator (Fig. 44) may also be employed to apply volatile substances to the middle ear. Sal-ammoniac vapour, inhaled into the naso-pharynx from a Godfrey's or other apparatus (Fig. 45), may be sometimes forced into the Eustachian tube by Valsalva's method. Probably, however, the vapour rarely reaches the tympanic cavity by this method.

The Value of Vapours. Vapours and gases are used mainly in the treatment of chronic dry catarrh of the middle ear. Their therapeutic effects are chiefly exerted upon the lining membrane of the cartilaginous part of the Eustachian tube, for probably only a small portion can pass beyond the *isthmus tubæ* into the cavity of the tympanum. The best effects are attained by the inflation of air impregnated with volatile substances. If the vapour or gas reaches the tympanum, a temporary feeling of fulness and pressure is often experienced, while a hot or even burning sensation is sometimes produced in the ear. The deafness or noises in the ear may, for a short time after, be aggravated.

Watery Vapour, either alone or impregnated with various medicaments, may be employed in the following way: A wide-mouthed bottle, containing the fluid to be vaporized, is closed with a cork having three perforations. A thermometer is passed through the central aperture, while the other two apertures are filled up by two bent glass tubes. To the outer end of the one is connected a piece of india-rubber tubing, attached to an air-bag, while the other is connected with another piece of tubing for conveying the vapour to the catheter. The air-bag has an opening in its side for the admission of air. The bottle is heated with a spirit lamp, and the vapour is forced into the catheter by compressing the air-bag while the air-hole is closed.

The Vapour of Sal-Ammoniac in the nascent state is highly spoken of by some surgeons. Three bottles are here required, containing respectively, strong ammonia, hydrochloric acid, and water slightly acidulated with sulphuric acid. The vapours of the two first substances are conveyed by glass tubes to the upper part of the bottle containing the acidulated water, and there the gaseous chloride of ammonium is formed. A tube leading from this bottle carries the vapour to a catheter which has been well inserted into the mouth of the Eustachian tube, and retained there either by means of a nasal clamp or the fingers of the patient. The vapour should be applied for four or five minutes each time. Slight coughing or retching, or a sensation of burning in the throat, may be excited during and after the application of the vapour.

The introduction of these vapours in this way is attended by considerable trouble, as well as some danger of injuring the ear, and the substances are more simply and probably more effectively applied in the liquid form as already described.

V. INCISION OF THE TYMPANIC MEMBRANE (MYRINGODECTOMY).

Instruments. Various forms of instrument are used for incising the membrane. Schwartze employs a strong, double-edged cataract needle. Politzer uses a lance-shaped, two-edged needle (Fig. 46, *a*), about two and a half inches in length, connected by means of a small screw with a handle, the arrangement being such that the incision in the tympanic membrane may be made either in a vertical or horizontal direction. Gruber employs a narrow, curved, sharp-pointed blade (Fig. 46, *c*), which can also be fitted to the handle to suit any direction in which the incision may be required. In these

instruments the blade or needle is connected to the handle at such an angle that the hand of the operator does not interfere with his view of the parts in the ear. The author prefers the small narrow blade of Gruber, because it takes up rather less space than the lance-shaped instrument.

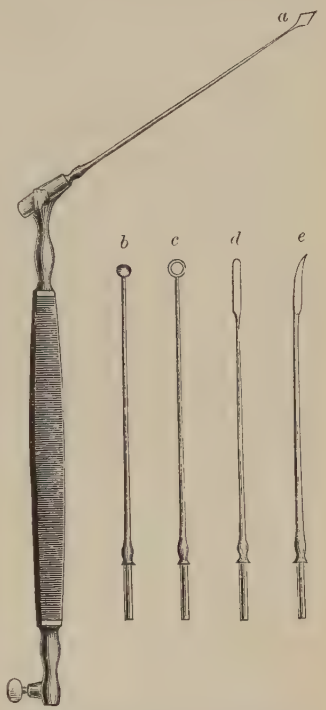

FIG. 46.—Various instruments suitable for the same handle—*a*, Lance-shaped needle for paracentesis; *b*, sharp spoon; *c*, ring knife for removing polypi; *d*, knife for cutting the posterior fold; *e*, curved blade for paracentesis.

Mode of Operating. In most cases the canal of the ear should first be cleansed carefully with an antiseptic and dried, while the middle ear should be inflated by Politzer's method, or with the catheter, in order to increase as far as possible the distance between the tympanic membrane and the inner wall of the tympanum. As wide a speculum as the canal of the ear will accommodate is introduced, and the interior is illuminated by means of a mirror attached to the head. The patient's head is firmly held by an assistant, while both patient and operator are seated. The auricle and speculum are supported as in the examination of the ear. The blade is passed through the speculum, and when the point is close to the part of the membrane to be incised the membrane is quickly pierced, and the opening at once enlarged to about three millimetres in length. If there is a distinct bulging of a particular part of the membrane, that is to be selected as the place for the incision. When there is no special bulging, a point midway between the umbo and the postero-inferior part of the periphery of the membrane is probably the most accessible part, while here also the membrane is pretty well removed from the inner wall of the tympanum. The antero-inferior quadrant of the membrane is also a suitable place for the incision, unless, as we sometimes find, the projection of the anterior osseous wall of the canal prevents access to this part of the membrane. The operator, if inexperienced, may fail from over-timidity to penetrate all the layers of the membrane, or he may make too small an opening. In the latter case the secretion in the cavity of the tympanum, especially if tough and stringy, cannot pass out. In order that the membrane may be completely penetrated in the full length of the incision,

he must, in cutting from above downwards, or from behind forwards, push the point of the instrument inwards while making the incision. This is required because, owing to the oblique position of the membrane, the upper and back part is nearer the hand of the operator than the lower and front part. The galvanic cautery is also used to perforate the membrane (see p. 80).

Escape of the Exudation. If the exudation in the middle ear be thin or serous it will immediately flow through the opening into the external auditory canal, from which it may be wiped away with absorbent cotton. If, on the other hand, it be thick and viscid, a small pearly-looking ball is usually seen protruding from the opening, and the patient—by performing the Valsalva experiment, or even simply blowing the nose—is frequently able to assist in its expulsion. But inflation by Politzer's method is often necessary to help in forcing out the secretion, while suction with Siegle's speculum may be of service. When the secretion consists of very viscid mucus, forceps may be required to pull it out of the opening in the membrane, and the mucus is sometimes thus drawn out in the form of a string.

It is occasionally necessary, before we are able to empty the tympanum, to soften or thin the secretion by means of solvent fluid introduced into the tympanic cavity. This may be done either by injecting eight or ten drops of warm water, or a weak warm solution of bicarbonate of soda, through the catheter and Eustachian tube into the tympanum. A simpler, though perhaps a less effectual method, consists in pouring the warm solution into the external auditory canal and allowing it to remain there for a few minutes, during which the tragus is frequently pressed in upon the fluid.

Incision of the tympanic membrane is usually attended by pain, sharp but momentary, unless there is distinct pointing of the membrane, when the operation is almost painless. A 10 per cent. solution of cocaine applied a few minutes before operation may be of service in lessening the pain. It is rarely attended by the escape of more than a mere drop of blood, and the wound usually heals very quickly. In twenty-four hours a black streak of dried blood marks the site of the incision, which has generally healed by that time. Inflammatory complication is rare, but it is a judicious precaution for the patient to rest in the house and avoid alcoholic stimulants for the remainder of the day after the operation.

Cases suitable for Incision. This operation is practised in two classes of cases: 1st, when there is purulent, mucous, or serous exudation in the cavity of the tympanum, or in the interstices

of the tympanic membrane; and 2nd, cases in which the membrane is thickened, adherent, atrophied, or indrawn.

The propriety of the operation in the former class of cases cannot be gainsaid, as it is based on ordinary surgical principles. With an acute purulent collection in the middle ear, where the tympanic membrane has become thickened and more unyielding in consequence of previous disease, the operation is eminently called for. In such a case timely incision of the membrane may prevent the extension of the disease to the labyrinth or to the meninges. In mucous or serous exudations in the middle ear, the operation is indicated, (*a*) when the quantity is so great as to cause a distinct saccular bulging of the membrane, especially at its posterior part; and (*b*) when the mucus is thick and viscid, although not in such quantity as to produce distinct bulging. Here the operation may avert important and permanent structural changes in the tympanum.

In the second class of cases the operation is undertaken in order (1) to make a permanent opening in a thickened membrane, (2) to incise the posterior fold or an atrophic part, (3) to separate adhesions or bands binding the membrane to adjacent parts, or (4) as a preliminary to the cutting of the tendon of the tensor tympani muscle. On the whole, experience seems to show that the operation of incising the membrane is of greatest value in cases of fluid exudations in the middle ear; and, in these cases, repeated inflation by Politzer's method is usually required for some time afterwards.

VI. RAREFACTION AND CONDENSATION OF THE AIR IN THE EXTERNAL MEATUS.

This is sometimes useful, especially in conjunction with inflation of the middle ear. The rarefaction and condensation may be produced either rapidly or gradually, and is sometimes termed *massage* of the tympanum. Rapid but moderate suction may be brought about by Siegle's pneumatic speculum or by Delstanche's pneumatic tractor (Fig. 47). A convenient method, which may be used by the patient at home, requires simply an air-bag and an india-rubber tube similar to that used for inflating the middle ear, substituting for the nasal piece an ear-piece of conical shape covered with india-rubber tubing, so as to make the closure

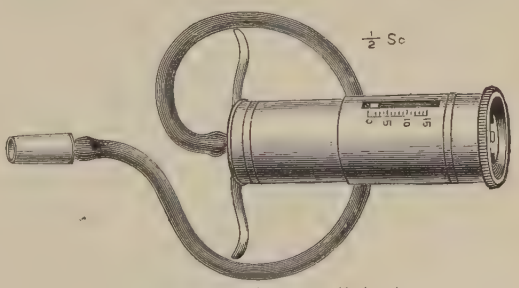

Fig. 47.—Delstanche's pneumatic tractor.

more complete. The air-bag is first compressed with the hand, and the ear-piece is fitted air-tight into the external auditory canal. The compression is then removed, when the air in the canal becomes rarefied, and traction is thus exerted on the membrane. This may be repeated four or five times at each sitting. A method of gradual suction has been suggested by Politzer, and consists in soaking a piece of cotton wool in oil, and making a firm plug of the size of a hazel nut, which is then packed into the cartilaginous part of the external meatus. This is done at night and removed in the morning. It is repeated two or three times weekly for two or three weeks, and produces the desired effect. Patients often say they are able to relieve unpleasant sensations in the ear by pressing the tragus for a moment inwards, and thus compressing and rarefying the air in the canal.

This method of treatment is called for especially when the tympanic membrane is much indrawn or retracted, along with adhesions, or retraction of the tendon of the tensor tympani muscle. The gradual method is also suitable where the membrane is flaccid or atrophied. In purulent cases a pneumatic tractor is sometimes employed to suck secretion out of the middle ear through a perforation.

VII. ELECTRICITY.

Electricity is employed in the treatment of ear disease, in the form of the continuous and the induced currents, as well as for its thermic effect (galvanic cautery).

For applying the continuous current, the writer uses a zinc and carbon battery having twenty-one cells, furnished with a commutator for reversing the direction of the current; and, for the interrupted current (Faradism), Dr. Spamer's portable induction apparatus.

Electrodes for the Ear. Various forms of electrodes are required, according to the method of application. The writer most frequently employs the current by way of the Eustachian tube and external auditory canal. The positive electrode is introduced into the external auditory canal, and consists of a conducting wire passing through a vulcanite speculum, the end of the wire being capped with a piece of sponge which projects from the inner end of the speculum (Fig. 48). When introduced, the sponge is in contact with the walls of the canal, or, by pushing the speculum farther in, is placed in contact with the tympanic membrane. Before introduction, the sponge

FIG. 48.—Electrode for applying electricity to interior of ear.

is moistened in a warm, weak solution of salt. The negative electrode consists of a conducting wire passing through a thin Eustachian catheter, the wire terminating in a small sponge at the inner end of the catheter (Fig. 49). When used, the point of the catheter is introduced well into the pharyngeal mouth of the Eustachian tube, and is held *in situ* by the patient. The positive electrode is sometimes placed at the outer orifice of the ear, or over the tragus, instead of in the canal, by means of a bent metallic stem having a ball-shaped extremity covered with leather, while the

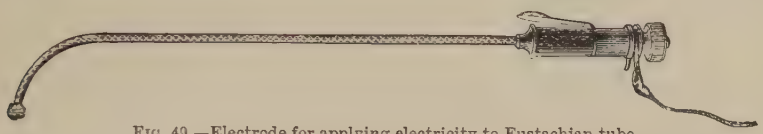

FIG. 49.—Electrode for applying electricity to Eustachian tube.

other electrode, having a similar shape, is placed over the side of the neck. Electricity is also sometimes applied by filling the canal of the ear with a warm solution of salt, into which the end of the electrode is placed. In galvanizing the sympathetic, one pole is placed under the articulation of the jaw at the inner edge of the sterno-mastoid muscle, and the other electrode in the situation of the lower part of the common carotid. In using the continuous current it is often advantageous to alternate its direction. Galvanizing the ear, for therapeutic purposes, should not be employed more frequently than twice a week, and only for eight or ten minutes on each occasion.

Precautions. We must not employ a current so strong as to excite pain, burning, marked facial contractions, flashes of light, loud sound, or giddiness. During the application a sensation of taste or contraction is sometimes experienced in the tongue, the impression being conveyed through the chorda tympani nerve lying on the inner aspect of the tympanic membrane.

The Value of Electricity in Ear Disease. There are great varieties of opinion among aural surgeons as to the therapeutic value of the electric current, some extolling it as one of the most valuable remedies, while others deny that it has any real or permanent usefulness. This difference of opinion is probably due to the uncertain data upon which we are able to select this remedy, or the form of electricity to employ. When there is evidence of hyperæsthesia of the auditory nerve, with subjective sounds in the ear, galvanic excitement of the nerve should be avoided. On the other hand, if there is torpidity of the nerve (dysæsthesia), there is reason to expect benefit from the employment of the galvanic current. When the acuteness of hearing is liable to marked

fluctuations which are not accounted for by changes in the middle ear, the galvanic treatment should be tried. In chronic adhesive catarrh of the middle ear, part of the impairment of hearing is probably sometimes due to functional disturbance of the nerve, which might be benefited by the galvanic current; and, at any rate, the nervous symptoms which sometimes exist in connection with that affection are occasionally relieved by electric treatment.

Faradism is applied generally with the object of acting upon the muscles of the middle ear. Paretic conditions of one or all of these muscles are undoubtedly present in a certain number of cases of deafness or tinnitus, and in such cases Faradism may be useful. It is most efficiently applied according to the first method described. The statement that Faradism has any beneficial effect in the way of shaking or loosening a rigid ossicular chain has no clear evidence to support it.

It has to be observed that either form, in some cases, seems to aggravate the noises in the ear, and, if so, this mode of treatment should not be continued.

The Galvanic Cautery. In the treatment of the nasal and pharyngeal cavities and of the ear, the galvanic cautery has of late years been largely employed, both for destroying morbid tissue and removing growths. In the ear it is chiefly used for cauterizing fibrous polypi and hypertrophied mucous membrane in the tympanic cavity, as well as for making an artificial opening in the tympanic membrane. The author has also removed on two occasions aural exostoses, having narrow pedicles, with the galvano-caustic loop. The handle of the cautery (Fig. 50) used by the author for ear work is small and light, and the arrangement for interrupting and restoring the continuity of the current is at one side. The insulated electrodes are very slender, and bent at an obtuse angle (Fig. 51). Hence when introduced into the ear they take up very little space, and the view is only very slightly obstructed.

Fig. 50. Handle of galvano-cautery for ear.

The Burner suitable for the ear consists of thin platinum wire, coiled in such a way as to present a small round disc to the diseased tissue (Fig. 51, *b*). A speculum introduced as far as the tissue to be cauterized prevents the burning of the walls of the canal. While good light is projected from a forehead mirror, the burner is introduced cold through the speculum. When it has been accurately applied to the morbid tissue, a slight pressure of the finger upon the spring at the side of the handle is instantly followed by

a red-hot condition of the burner and the thorough cauterization of the tissue. This is accompanied by a hissing sound and the obscuring of the parts by vapour. For about two seconds the tissue is exposed to the red heat, and then the current is interrupted. The burner almost instantly cools, and the instrument is withdrawn. If required, the burner may be reintroduced and reapplied two or three times at one sitting. It is very important that the moisture should be carefully removed from the part to be cauterized before the application of the burner, otherwise a longer contact with the tissue is required. The author has not seen any serious inflammation result from the use of the galvanic cautery. The pain, while somewhat sharp at the moment of application, rarely if ever continues.

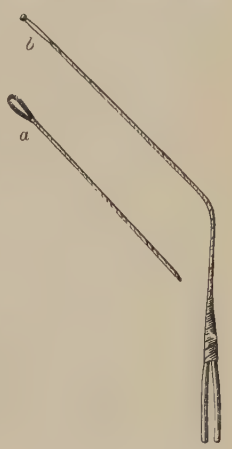

FIG. 51.—Burners for ear.

The battery which the writer employs consists of eight large plates, four of zinc and four of carbon arranged alternately. The zinc plates are united and the carbon plates united, the two sets being connected through the electrodes; in this way the maximum thermic effect is attained. The plates are held together by an iron rod covered with vulcanite, and passing through holes in the plates. A brass handle is attached to this rod, by which the plates can be moved as desired. The fluid consists of a 10 per cent. aqueous solution of bichromate of potash, to which the same proportion of sulphuric acid is added. Eight pints of this are contained in an oval earthenware basin, giving a depth of six inches of fluid. This vessel with the fluid lies on the floor of a wooden box. A wooden rack, having eight spaces, is fixed on each side of the box; and these spaces accommodate the ends of the iron rod which supports the plates.

This is a convenient form of battery, for it emits no smell, and the plates require no cleaning after being used. The fluid need not be changed oftener than once in three months, although the battery is employed daily. It is always reliable, and after finishing an operation, one simply requires to lift the plates into the upper part of the rack, and close the door of the case.

VIII. MECHANICAL AIDS TO HEARING.

Mechanical contrivances for concentrating or strengthening the effect of sound upon the ear are sometimes of great benefit to persons whose hearing is very defective. Most frequently a deaf person uses his own hand or fingers to press the auricle forwards and outwards or to increase the reflecting surface behind, so that the sound waves coming from a point in front of him are more completely caught and reflected into the ear. This simple method is often a considerable help.

Aids to Conversational Hearing. As an artificial aid to the

hearing of speech, when the speaker is near, as in ordinary conversation, a flexible conversation tube (Fig. 52, 2) is the most effective. This is about three feet in length, composed of silk or wool woven upon a tube of iron wire arranged spirally, and having a mouth-piece and an ear-piece made of horn. The mouth-piece should be funnel-shaped, and about two inches in diameter at its outer opening. During use the mouth-piece is held in front of,

FIG. 52.—Mechanical aids to hearing (Argyle Rubber Co., Glasgow).

but not in contact with, the speaker's mouth, and ordinary loudness of speech is employed. The ear-piece is acorn-shaped, smoothly rounded, and is placed in the external orifice of the patient's ear. It should be bent almost to a right angle about an inch from the end, and the horn should extend from four to five inches, so that the hand of the patient may not wear and impair the flexible, softer part of the tube. Such a tube can be conveniently coiled and carried in the pocket. When the external meatus is very irritable, the ear-piece should be shaped like an oval shell (Fig. 52, 3), and made to cover the auricle accurately. For use at table a longer tube with a wider mouth-piece, which may rest on a suitable

stand, is sometimes convenient (Fig. 52, 5). There is greater concentration of sound if the tube becomes gradually somewhat narrower from the mouth-piece to the ear-piece.

Aids to Distant Hearing. It is much more difficult to enable the deaf patient to hear a speaker at a distance. Probably the most suitable instrument for this purpose is a conical tube having a wide mouth, shaped like a speaking trumpet or horn of a cow, and made of silver, vulcanite, or horn, the ear-piece being placed at a right angle with the rest of the tube. A parabolic metallic cup fitted to a tube with an ear-piece (Fig. 52, 6, 7) is found by some persons to be more effective than the simple wide-mouthed, conical tube. An instrument such as that depicted in Fig. 52, 1 is found to be very useful and gives less fatigue in holding.

In imitation of the efforts of deaf patients to improve their hearing by placing the hand behind the ear, ear-shells are made to fit on to the auricle, increasing the surface of the latter. This form is specially suitable for those whose auricles have been much flattened by the compression of caps, etc., and is, to the patient, probably the most agreeable, though not the most effective. A flattened, curved tube, covered when in use with silk, and fixed by a spring to the head, is more useful (Fig. 52, 4).

Small Instrumental Aids. Small instruments, invisible during use, for augmenting the hearing power are in great request by deaf persons, who, in consequence of their inclination to conceal their infirmity, dislike and delay the employment of the somewhat conspicuous appliances just described. These so-called invisible tubes are generally worthless, except in cases where the defect of hearing is due to collapse of the cartilaginous walls of the canal. Politzer has introduced a small tube, the shape of a hunting horn, made of vulcanite and about an inch in length (Fig. 53). The narrow end is introduced into the meatus, and the mouth of the wider end is directed to the hollow of the concha. The object of this contrivance is to increase the normal effect of the inner surface of the tragus in reflecting the waves of sound, coming from the concha, into the external canal. Politzer has found that, in about three-fourths of the persons on whom he has tried the instrument, the hearing was improved, on an average, to the extent of double their ordinary distance, while in one fourth the hearing was either not improved or made worse. The writer has not experienced such good results.

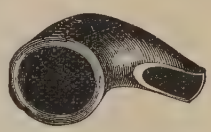

FIG. 53.—Politzer's small hearing tube.

Value of Aids to Hearing. In any given case we should try each of these various contrivances, until we find the one which is

most beneficial. The improvement of hearing derived from the use of one or other of these instruments is often of great benefit to deaf persons, and the relief to their friends is also a not unimportant advantage. It is to be remembered, however, that some persons with *hyperæsthesia acoustica* cannot tolerate the use of the hearing tube, owing to the painful sensation produced upon the ear when words are spoken into it. These aids are not to be employed in cases of recent deafness from acute inflammations. In old standing cases, however, there is no objection to their use, provided they prove comfortable and beneficial. Indeed, by applying to the auditory nerve its proper stimulus—sound vibrations—the use of these appliances may prevent or delay the atrophy which is apt to result from the deprivation of the proper stimulus of the nerve.

The Audiphone was introduced from America with fair promises, but unfortunately the test of experience has proved its performances to be very meagre and disappointing. It consists of a thin plate of vulcanite, nine inches by ten inches, furnished with a handle. By means of a silk cord it may be bent to any degree of curvature and tension. Before the instrument is used, the cord is pulled so as to give the required curvature, and the upper edge is placed in contact with the upper incisors, or pressed between the upper and lower incisors, while it is held with the convexity forwards. The conduction of sound through the bones of the head is the basis of this American invention, and it is asserted that the waves of sound coming from the speaker's mouth and falling upon the convex surface are transmitted to the teeth, and thence through the bones of the head to the labyrinthine fluid and nerve, independently of the external and middle ear. Theoretically this is a very reasonable direction in which to seek for a means of helping those deaf persons whose auditory nerves are healthy, and where serious obstacles exist to the normal transmission of sound through the conducting part of the ear. But in making use of osseous conduction the vibrating body must be placed in contact with the bones of the head; and while, in the case of a deaf person whose auditory nerves are intact, the music of a piano may be quite well heard, if the vibrating sounding board is directly connected by means of a rod of wood with the teeth or bones of the head, it is very different if there is not the direct connection of a solid sound-conducting substance. What has yet to be discovered is a solid substance which shall have the property of being set into vibration by waves of sound, transmitted through the air, of no greater intensity than those produced by the human voice in ordinary conversation. The audiphone is possessed of this property to only a very small extent, and hence we find that it is quite useless in the great majority of cases. Out of very many cases in which the writer has tested it, he can remember only two in which it was clearly useful, and in these a piece of cardboard, bent, and in a state of tension, was equally serviceable. While it is generally useless in aiding the hearing of speech, it is probably more effective in enabling a very deaf person to hear loud music.

A rod of wood connecting the larynx of the speaker with the teeth of the deaf person has been suggested as a means of enabling a deaf person to hear speech.

IX. THE ARTIFICIAL TYMPANIC MEMBRANE.

Yearsley, in 1848, was the first in this country to draw attention to the improvement in hearing which is sometimes produced by placing a moistened pellet or ball of cotton wool over the remains of the tympanic membrane in cases of perforation.

Toynbee's Artificial Tympanic Membrane. Toynbee, making use of the suggestion, introduced in 1853 his so-called artificial drum (Fig. 54), which consists of a disc of india-rubber connected with

FIG. 54.—Toynbee's artificial "drum."

FIG. 55.—Keen's tube with probe for introducing artificial "drum."

a silver wire. This silver wire is fixed at the one end into the centre of the disc, by means of two very fine silver plates, while the outer end of the wire is formed into a ring for convenience of holding. Modifications of the original membrane of Toynbee are used by some surgeons. Gruber substitutes for the wire a thread, which is passed through the centre of the disc. The disc is, in this case, introduced into the ear by means of forceps, or of a vulcanite tube. The thread is passed through the tube so that the disc rests on the inner end of the tube. This is introduced, pushing the disc before it, until the latter is placed in proper position, when the tube is withdrawn. Keen has improved this by combining the tube with a probe (Fig. 55). A small piece of soft lint is sometimes used instead of india-rubber. A fine india-rubber tube, cemented at its inner end to the disc, is also sometimes employed instead of the wire. Whichever of these modifications is used, the disc should be cut to the proper size, and, before being introduced, it should be moistened with warm water or vaseline. If we use Toynbee's membrane, or any kind of disc with a wire attached, the latter is held by its ring-formed end, and the disc is gently pressed down the canal of the ear, till there is a feeling of obstruction, when it will usually be found to rest on the remains of the membrane. If it produces a ringing in the ear, or other unpleasant feeling, or if no improvement in hearing takes place, its position should be modified. Several alterations are often necessary before it is efficient and comfortable, and after a little practice the patient is better able than the surgeon to make these adjustments. When it acts efficiently, the patient often knows simply by the sensation in his ear; or he finds, by applying such a test as creating a slight noise with his finger-nails or the rustling of his clothes, that he hears better.

Yearsley's Pellet of Cotton. The use of the cotton ball or pellet of Yearsley (Fig. 56), or some modification of it, is now generally preferred by aural surgeons to the india-rubber disc. The cotton is sometimes used dry, especially when it is intended to soak up moisture in the ear; but a moistened ball or disc of cotton is, in the author's experience, much more efficacious in improving the

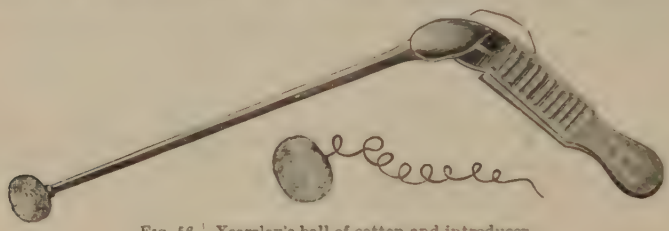

FIG. 56.—Yearsley's ball of cotton and introducer.

hearing. It may be moistened with glycerine well diluted with water, or with fluid vaseline. If there is still suppuration, it may with advantage be soaked in a suitable antiseptic solution. The cotton may have the form of a ball (Fig. 56), or it may be

FIG. 57.—Forceps for patient's use in introducing cotton pellet.

FIG. 58.—Patient introducing disc of cotton. (Yearsley's "drum.")

disc-shaped, while a piece of thread attached to it, which lies in the canal of the ear while the cotton is in position, enables the patient to remove it at will. The cotton is introduced by means of fine forceps having a weak spring (Fig. 57). When the surgeon has satisfied himself of the usefulness of the cotton pellet, he should carefully instruct the patient in the method of introducing and

withdrawing it (Fig. 58). Very frequently, after such training, the patient becomes much more dexterous than the surgeon in manipulating the cotton wool in the ear.

The use of the cotton has the following advantages over Toynbee's artificial membrane: 1st, It is softer and excites much less irritation; 2nd, it is a convenient medium for applying medicaments to the interior of the ear; 3rd, it does not cause disagreeable noises in the ear during chewing, as does the wire of Toynbee's membrane; 4th, it is not visible at the orifice of the ear. In very few cases, indeed, is the india-rubber disc useful when the cotton pellet fails.

Proper Situation. The efficacy of either form depends very much on the precise place to which it is applied, and the degree of pressure exerted by it. The situation where it is most likely to be beneficial is the upper and back part of the inner wall of the tympanum, over the situation of the stapes. The next most likely place is the upper part of the manubrium. If the perforation is small, we should try the application of a small cotton disc over it. But in determining whether, in a given case, this mode of treatment will prove useful, we must patiently and carefully try the moist cotton pellet on one spot after another with varying degrees of pressure. In many cases we must, before admitting failure, repeat our efforts at two or three different times. As a rule, when we hit upon the proper place we have the good effect immediately; but the author has known patients who found no benefit until it had remained in the ear several hours.

Precautions in the use of the Artificial Drum. When we find that this method of improving the hearing is successful, caution should at first be exercised so as to avoid irritating the ear and producing inflammation or suppuration. Great variety is met with among patients in regard to the irritability which may be produced by such a foreign body as a piece of india-rubber or cotton wool. In a small number it is quite impossible to wear it owing to the irritation produced by contact even for half-an-hour; while, on the other hand, we meet with those whose ears can tolerate the contact of moist cotton wool for months at a time without inconvenience. In a large number of persons it is well at the beginning to limit its use to one hour each day for a few days, gradually extending the time until we reach eight or ten hours per day. Unless there is remarkable tolerance of their contact, neither form should be used at night. During the first few days the patient should be seen daily, and it is well, at first, that the cotton employed should have a piece of thread attached to it, so that the patient may, after the allotted time has expired, remove it. When acute inflammation exists in the ear, or when there is profuse suppuration, no form of

artificial membrane should be applied until these conditions have been removed. It should not be persisted in when its most limited use excites inflammation or giddiness; it is also inapplicable to young children. Generally we should not recommend it in persons whose hearing is very good in one ear, or even, although both ears are affected, where the deafness is not marked.

Value of the Artificial Drum. These artificial helps to hearing have sometimes an excellent effect, restoring deaf persons from solitude to all the enjoyments of society. Many persons, without such aid, can hear speech only when spoken close to the ear, while with the aid of a pellet of cotton wool properly adjusted they hear ordinary conversation perfectly well. Even in cases of almost total deafness decided improvement is occasionally effected, although, as a rule, when the deafness is extreme no benefit is produced by the artificial tympanic membrane. Slight improvement is very common, and even such moderate improvement may be of great value, perhaps averting exclusion from public meetings. The experience of the writer accords with that of Politzer, that an occasional pause of a few days is often followed by still better hearing. We now and again find that improved hearing continues for some time after the removal of the cotton.

It has to be admitted, however, that in a number of cases the artificial support has no effect in improving the hearing, although with greater experience most aural surgeons feel that the number of such cases becomes less. We cannot in any given case determine merely from the pathological conditions present whether this mode of treatment will prove beneficial. The test of experiment is our only guide. Such a test is sometimes provided by the patient before coming to us. If he informs us that the pouring into the ear of a few drops of oil, glycerine, or water has the effect of improving the hearing for a time, we shall probably find that the moist ball of cotton has a beneficial effect on it. It is in some cases very disappointing to find, while improvement takes place in hearing the tick of a watch, that there is no change in the hearing of speech.

How the Improvement is Effected. The way in which the improved hearing is brought about by the artificial tympanic membrane is not fully understood. It is certain that this is rarely due to the mere closure of the gap in the membrane; indeed this has often an injurious effect on the hearing. The good effects are probably produced, in most cases, by pressure exerted upon some part of the ossicular chain, either directly or through the intervention of the remnant of the tympanic membrane. When, on account of disarticulation between the incus and stapes, or when a portion or

the whole of the incus has been removed, the continuity of the ossicular chain is lost, the stapes is deprived of its proper support, and fails to exercise a due amount of pressure upon the fluid of the labyrinth. The application of the cotton pellet, by pressing upon the manubrium or upon the long process of the incus, probably restores the continuity of the chain, or, if the incus is gone, the pressure exercised upon the stapes by the artificial support may restore the due amount of pressure upon the labyrinthine fluid. We frequently find that the cotton wool has to be well pressed into the situation of the stapes before a beneficial effect is secured.

Advantage to the hearing has been sometimes derived from the pressure of a moist disc of cotton wadding upon the tympanic membrane, when the latter was not perforated. We may suspect in such rare cases that the continuity of the chain of bones has been, from some cause, disturbed.

X. THE OPERATIVE TREATMENT OF AURAL POLYPI.

The safest, simplest, and most effective means of removing a polypus from the ear is by encircling it with a wire loop, as near the root as possible, and then constricting and severing the growth. The instrument used for this purpose is Wilde's snare or some modification of it.

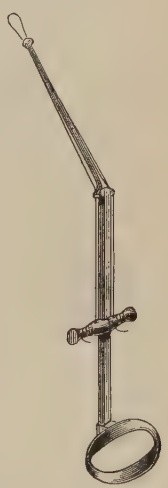

Fig. 59.—Wilde's snare for removing aural polypi.

Wilde's Snare (Fig. 59) consists of a steel shaft bent near the middle at an obtuse angle. To the outer end is attached an oval ring for the reception of the thumb of the operator. The inner end, for introduction into the ear, is about the twelfth of an inch broad, smooth, rounded, and perforated by a short canal at each side for the passage of the wire. At the angle of the shaft there are also two canals for the reception of the wire. A movable cross-piece perforated by two canals is connected with the outer part of the stem. The end of the wire is first passed through the three canals on the one side, beginning with the cross-piece, and then through the three on the opposite side, beginning at the inner end. A loop of the size desired is then formed by drawing down the two ends of the wire, which should afterwards be fixed by winding them round the cross-piece. When the latter is pressed down with the index and middle finger, any object which may be encircled by the loop is constricted. The growth is more effectually divided with the wire if there is a groove on the distal end of the stem for receiving the wire when the loop is tightly drawn. There are various modifications of Wilde's snare. In one (Blake and Gruber) a straight stem, having a ring on its under surface for the index finger, is connected with a handle, at an obtuse angle, by means of a fixed screw. Various other instruments, such as a probe, a paracentesis needle, etc., may be substituted for the stem, so that the one handle serves for different purposes. In another modification, instead of a solid stem there is a

tube through which the wire is passed – this is intended to ensure the complete penetration and division of the growth in order to avoid the necessity for

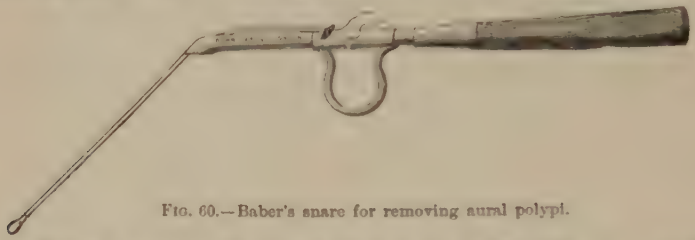

Fig. 60.—Baber's snare for removing aural polypi.

traction. Baber's is one of the best of this variety (Fig. 60). In regard to the loop, for small soft polypi well annealed iron wire is suitable. If the tissue of the polypus is firm and tough, fine steel wire or thin platinum is necessary. Cat-gut is employed by some, and fine fishing gimp is recommended by Dalby. The objection to these two last substances is that, on account of their softness, it is not so easy to encircle the growth, especially when the situation is not very accessible.

Mode of Operating. In using Wilde's snare, where the polypus is so large as to protrude from the outer orifice of the ear, the affected side is turned towards good light, and, by means of a probe

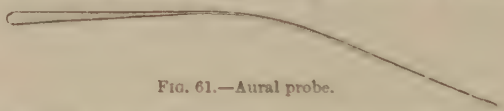

Fig. 61.—Aural probe.

(Fig. 61) the length of the polypus and, if possible, the position of its attachment are ascertained. The snare is then held by means of the thumb in the ring, while the index and ring fingers support the cross-piece. The wire loop, bent at a suitable angle to the stem of the instrument, is made to encircle the outer end of the growth, and then gently insinuated, by a kind of rotatory movement, as far as is possible without exciting very great pain. The cross-bar is then firmly pressed down towards the thumb, and the growth is completely divided, or tightly constricted and pulled out by the root. We can rarely remove the whole of one of these large polypi at the first sitting, as it is seldom possible to place the loop at the very root. When we get access to the deep part of the ear, we may find not only the remaining portion of the large polypus, but also other smaller ones occupying the interior of the ear. We frequently find it necessary to use the snare, at intervals of a day or two, several times, before we are successful in clearing away the whole of the morbid tissue. The bleeding is sometimes considerable, but is usually quickly staunched by pressure with a cotton plug.

When the polypus is not so large as to appear at the outer end of the canal of the ear, the operation must be done with the aid of the forehead mirror and as wide a speculum as possible. The

position of the polypus and its point of attachment should be first determined with the aid of the probe, and the loop is made to encircle it, with the greatest gentleness possible. For young children an anæsthetic may be necessary. For the after treatment of polypi, see Chapter XII.

XI. OPERATIONS ON THE MASTOID PROCESS.

We are much indebted to Schwartze, Macewen, Barker, and others for placing these operations on a scientific basis, by pointing out the anatomical difficulties to be encountered, the proper mode of operating, and the indications which call for operation.

Indications for Operation. Operations on the mastoid are performed mainly for the following conditions: (1) Acute purulent collections in the mastoid cells. (2) Purulent affections of the middle ear, with carious erosion of the cortex of the mastoid, either behind the auricle or in the posterior wall of the canal. (3) Chronic purulent processes in the middle ear, which have proved intractable to all ordinary forms of treatment, especially where cholesteatomatous masses have formed, or the existence of sequestra is suspected. (4) Intra-cranial complications of purulent middle ear disease, as preliminary to opening the intra-cranial cavity. (5) Cases of dangerous retention of pus from stenosis of the external auditory canal.

Structures in danger. The parts which may be endangered are (1) the sigmoid sinus in the posterior fossa of the skull, (2) the dura mater, either in the posterior or middle fossa, (3) the facial nerve, and (4) the external semicircular canal.

Distinction between Acute and Chronic Cases. It is important to note that the operation for the relief of an acute purulent collection in the mastoid cells is much simpler and usually more satisfactory than that undertaken for the cure of chronic conditions. In the former case an opening is made through the shell of bone forming the outer wall of the vertical part of the mastoid cells, where in acute cases the purulent collection is most frequently to be found. In chronic conditions, on the contrary, we have to penetrate much more deeply, so as to open the antrum and, it may be, the attic of the tympanum, while owing to the sclerotic condition of the bone, which is commonly found in these cases, the difficulty of penetrating this and the danger of injuring neighbouring structures are much greater.

Preparations for the Operation. Besides the chloroformist, one assistant is required to take charge of the retractors, another to mop out the cavity in the bone, one to work the dental engine, and another to change the burs and hand instruments to the operator.

After the hair has been shaved from the neighbourhood, the skin is well washed with soap and hot water, and a piece of lint moistened with a 1 in 40 solution of carbolic acid is kept in contact with the skin for several hours before the operation. The instruments are immersed for some time before the operation in a 1 in 20 solution of carbolic acid, while during the operation they are placed in a 1 in 40 solution. The ear should also be carefully syringed with an antiseptic solution and dried. If polypi or granulation tissue are found in the ear they should first be removed.

Exposing the Bone. After the patient has been anæsthetized by chloroform or ether, the auricle is held forward by an assistant, while an incision is made through the soft parts immediately behind, and parallel to, the auricle. To control the posterior auricular artery, the finger is pressed on the bone near the tip of the mas-

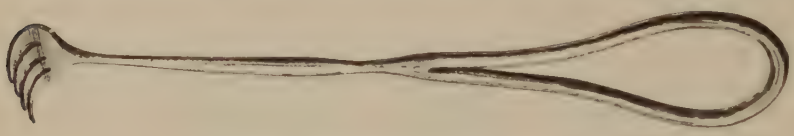

Fig. 62.—Retractor for mastoid operation.

toid, from which the incision is carried upwards from one to two inches so as to extend to half an inch above the supra-mastoid ridge, the soft parts being completely divided down through the periosteum to the bone. The greater the œdematous swelling over the bone the longer should be the incision. The soft tissues, including the periosteum, are raised from the bone and pushed well forwards. By means of a retractor (Fig. 62) in charge of an assistant, the anterior parts are strongly drawn forwards to expose, or allow the finger to feel, the postero-superior rounded edge of the bony portion of the external auditory canal. In many cases, especially if the posterior wall of the canal has to be removed, the periosteal lining of this part of the meatus should be separated with a small bent spatula and pushed downwards and forwards (Fig. 65, *a*). The posterior edge of the wound is also drawn backwards with a retractor, so as to expose a sufficient surface of bare bone. The bleeding can usually be checked by simple pressure, or self-clamping forceps applied to spurting vessels: the ligature

Fig. 63. Burs used in perforating the mastoid.

is seldom required. Portions of iodoform gauze, dry or soaked in very hot water, are freely used to staunch the oozing, which is sometimes troublesome. It is important to clear the field of operation as thoroughly as possible of blood. Bleeding from the bone when chiselling or burring is to be dealt with by prolonged pressure with iodoform gauze.

FIG. 64.—Gouge and chisels for mastoid operations; *a*, gouge; *b*, straight chisel; *c*, curved chisel.

FIG. 65.—*a*, Instrument for separating periosteum of meatus; *b*, hooks for removing contents of attic; *c*, small scoop.

Perforating the Bone. A careful examination of the surface of the bone is now made, and, if it is found to be soft, or if the cortex is very thin, as in the young child, a sharp gouge (Fig. 64, *a*) will be sufficient to perforate the cortex. If the cortex, however, is firm and sound, and our intention is to reach the antrum, the perforating instrument is applied to the surface of the bone below the supra-mastoid ridge, slightly behind and below the level of the roof of the external auditory canal. If this ridge cannot be found, the instrument should be applied close to the junction of the mastoid surface with the external auditory canal, just behind the level of the roof of the canal (Fig. 67). Professor Macewen opens the bone in the *supra-meatal triangle*—a space formed by the posterior root of the zygomatic process above, the postero-superior segment of the external auditory canal, and a perpendicular line passing through the hindermost part of the edge of the canal joining them (Fig. 67). As it has been forcibly expressed, we should *hug* the posterior wall of the canal; here there is safety.

FIG. 66. Volkmann's spoon.

Chisel and Mallet. The method of operating upon the bone employed by most operators, especially in Germany, is to remove, by means of a chisel or sharp gouge (Fig. 64)

and a hammer, layer after layer of bone until the interior of the antrum or mastoid cells is reached. In this way it is justly claimed that the field of operation is constantly before our eyes, and there is not the same danger, as in the use of a trephine or bone perforator, of propelling the point of the instrument inwards upon the dura mater or sigmoid sinus. The chisel, held at an angle of 45 degrees to the surface, with the bevelled edge uppermost, is worked with a hammer inwards, in a direction downwards and forwards. While admitting

FIG. 67.—Temporal bone, showing, A, supra-meatal triangle, from the posterior base of which is the safest position for perforating the mastoid in order to open the antrum; B, the situation for perforating in acute purulent formations in the *vertical* mastoid cells; C, shows the commonest situation of the sigmoid sinus; D, the dotted line above marks the situation, about an inch inwards, of the facial nerve; E, the posterior root of the zygomatic process, or supra-mastoid ridge, corresponding with the floor of the middle cranial fossa.

that this mode of operating has been very successful in the hands of many operators, the concussions of the hammer are not free from risk in certain intra-cranial conditions, while the chisel and hammer are unsafe when working in the deep parts, unless in very experienced hands. The large amount of bone which must be removed in operating safely with the chisel leaves behind a condition of the mastoid which is objectionable from an aesthetic point of view.

The Dental Bur. The writer now rarely uses the chisel and

hammer since Professor Macewen drew attention to the globular dental bur (Fig. 63), which is quite different from a boring instrument, and which, with the help of a gouge, he finds more safe and satisfactory than the chisel and hammer. It is important to employ burs which are very hard and sharp, and those made at White's Dental Manufactory, Philadelphia, are at present much the best. A dental engine of considerable power, either worked with the hand or foot, is required. The hand-piece is held like a pen and the lateral part of the bur is applied to the bone, which, as the bur rapidly rotates, is raised in flakes. To prevent excessive heat from developing, as well as to allow of inspection of the parts, the bur should be momentarily removed every few seconds. When we are working deep in the bone, and especially if the osseous tissue is soft, a sharp gouge, or the chisel without the hammer, will give effective aid.

FIG. 68.—Horizontal section through external meatus and mastoid process, showing the sigmoid sinus near to the surface, and close to the posterior wall of the external meatus. (Politzer.) *a*, Sigmoid sinus; *b*, floor of meatus; *c*, cavity of tympanum.

It is generally possible with this instrument to avoid wounding any structure, in however close proximity it may be. As Professor Macewen observes, "Dark apertures, or a membrane such as a pyogenic membrane or the sigmoid sinus or dura mater, are readily seen on the white polished surface made with the bur." Even although there may be abnormality in the relative positions of the interior of the cranium and the outer parts, such as unusual depth of the middle fossa (brachycephalic skull) or a position of the sigmoid fossa exceptionally far forward and near the surface (Fig. 68), the dura mater or sigmoid sinus need not be injured, although exposed.

Operating in Acute Cases. In the cases associated with acute purulent inflammation, the pus will usually be found further back, rather lower down, and more superficial than in chronic conditions (Fig. 67, *b*). It may have no direct communication with the antrum. The writer has occasionally found that, after reaching the pus cavity in the bone, the pus seemed to ooze from behind—from the direction of the occipital bone—and in some cases it came from the neighbourhood of the sigmoid sinus. In these acute cases we rarely require to penetrate very deeply with the bur, and, when the pus appears, the use of a gouge removes the cario-necrotic debris and granulations, which are usually found in the abscess cavity, as well as the surrounding softened

carious bone. In some instances, however, it is necessary to expose the sinus.

Operating in Chronic Conditions. To reach the antrum one must penetrate inwards and forwards, which is the direction of the posterior wall of the external auditory canal. If the tympanic membrane is gone, we may gain information of the distance to which we may safely penetrate by measuring the distance from the outer edge of the osseous external auditory canal to the inner wall of the tympanum. The depth of the antrum varies very much. In young children it is usually pretty superficial, perhaps no more than one-eighth of an inch, and easily reached. In the adult, on the other hand, it may be very deeply placed, even to the extent of three-fourths of an inch; and, when reached, it may be very small: it is even occasionally obliterated. When great depth is associated with eburnated ivory bone from sclerosis, the task is a formidable one. If, in such cases, the sigmoid sinus is situated close to the posterior wall of the canal (Fig. 68), the difficulty of reaching the antrum is almost insuperable. The bur is then especially desirable: and with such an instrument the author has repeatedly come upon the sigmoid sinus as well as the dura mater at the roof of the antrum without inflicting injury.

Condition of the Antrum. In these chronic cases the antrum is sometimes found surprisingly *high up*, even above the level of the supra-mastoid ridge. When the antrum is reached, a careful examination by means of a probe should be made of its walls and all softened or diseased bone removed with the gouge or bur: likewise granulation tissue, cholesteatomatous masses, osseous debris, and pus, which generally occupy the antrum, should be cleared away. The walls may be soft from carious processes, but frequently they are extremely hard, so that the strongest gouge produces no impression upon them. When the inner wall of the antrum is black or in a state of caries, and symptoms point to thrombosis of the sigmoid sinus, the sinus should be uncovered: purulent matter or granulation tissue may then be found surrounding the sinus. In other cases it may be proper to remove the roof of the antrum in search of an extra-dural abscess in that situation (Fig. 71).

Opening into the Attic. When the antrum is freely opened and all the morbid material removed or scooped out, it is in many cases desirable to work cautiously into the attic with a small bur through the *antro-tympanic* passage under the roof of the middle ear. When the attic is far forward this is a difficult and sometimes impossible task. In favourable cases we may, with small scoops and hooks (Fig. 65), remove not only the inflammatory products found therein, but also the malleus and incus if these exist. In many cases, in order

to reach the attic, it is necessary to remove the inner end or even the whole of the postero-superior wall of the canal (see p. 100). In this part of the operation the facial nerve is apt to be injured. In order to prevent this, we should work *high up* and avoid the inner wall of the antro-tympanic passage. Below the level of the floor of the antro-tympanic passage, the facial nerve takes a curve downwards and outwards (Fig. 69) and it may be injured by the operator. This is undoubtedly a risk in all cases, and its injury may be inevitable when the nerve is denuded of bone and embedded in granulation tissue (Fig. 70).

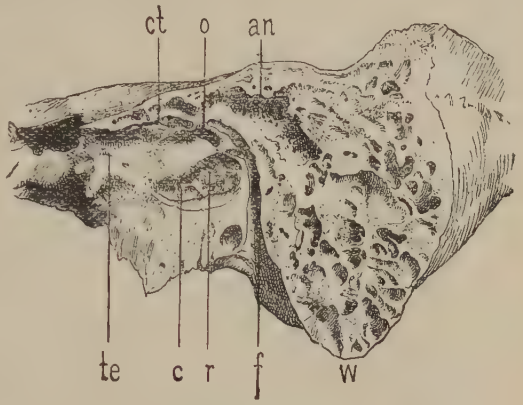

FIG. 69.—Sagittal section through the roof and floor of the tympanic cavity, showing the course of the facial nerve. *te*, Osseous Eust. tube; *ct*, canal for tensor tympani muscle; *c*, floor of tympanum; *o*, fenestra ovalis; *r*, fenestra rotunda; *an*, antrum; *f*, canal for facial nerve; *w*, mastoid process. (Politzer.)

When working in the deep region, good light with a reflector on the forehead is necessary. The corresponding side of the face should be carefully watched so as to detect the slightest twitch which might indicate dangerous proximity to the facial nerve.

A Carious Opening may already exist in the mastoid process with or *without* a sinus through the soft parts over the mastoid or posterior wall of the canal. The carious opening is often found after cutting down upon and liberating purulent matter between the bone and the periosteum. If a sinus exists in the soft parts, a perpendicular incision, from one inch to an inch and a half in length, is made through the fistular opening in the skin, and the periosteum is raised from the neighbourhood. The carious opening is then scooped out

FIG. 70.—Inner half of temporal bone, showing facial nerve denuded of its bony covering above and behind in the tympanic cavity. The nerve was embedded in granulation tissue. A, Lower part of facial nerve; B, antrum; C, carious apertures on inner tympanic wall; behind and above C is the exposed facial nerve; D, mastoid process (sclerosed); E, carotid canal.

with a gouge or a Volkmann's spoon (Fig. 66) having a good sharp edge, or it may be widened with the bur, so as to expose the antrum and entrance to the attic. If any piece of loose necrosed bone is found it should be removed, as well as cholesteatomatous matter, granulation tissue, or carious debris. Sometimes a long narrow canal is found perforating thick sclerosed bone; we should, with the bur, widen it in the direction of the antrum.

Occasionally the disease is localized in the *lower* part of the mastoid process: in such a case the pus from the mastoid cells may

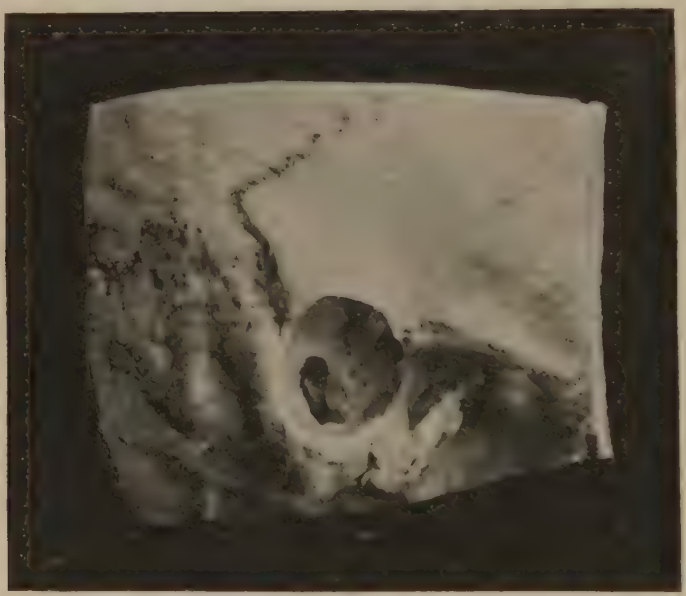

Fig. 71.—Temporal bone, showing large opening made with bur and dental engine, leading into antrum and attic, with two branch openings; the one behind exposed the sigmoid sinus, and the other, further in, exposed the dura mater over the roof of the antrum. Patient died from cerebral abscess and purulent meningitis.

find its way through the *inner* surface of the mastoid, near its tip, into the digastric groove; this is termed *Bezold's perforation*. In this case the pus usually burrows deeply in the neck, forming a large brawny swelling. In such a complication the mastoid must be freely opened near the apex, or the latter may have to be entirely removed.

After-Treatment in Mastoid Operations. The exposed cavities in the bone and the wound cavity should be thoroughly irrigated with an antiseptic solution, such as a 2 per cent. solution of carbolic acid, or a 1 to 4000 or 1 to 5000 solution of bichloride of mercury, so as to cleanse away all the bone dust and cholesteatomatous or other debris, with pathogenic organisms, which may still remain in the recesses of the middle ear. The parts should then be carefully dried by packing with strips of iodoform gauze. In acute cases

it is preferable to avoid syringing through the cavity behind to the external auditory canal or *vice versa*. In chronic conditions, on the other hand, thorough cleansing in these directions is essential, and at first a strip of gauze should be introduced through the antrum, attic, and external auditory canal. The dry treatment should, in the first place, be adopted. The spaces are partly filled with iodoform and boracic acid (one of the former to four of the latter), and stuffed with iodoform gauze. A wood-wool pad for absorbing the exudation of bloody serum, which follows the operation during the first twenty-four hours, is placed over the mastoid and side of the head, with an aperture for the auricle, and a bandage is applied over all. If no moisture appears on the outer surface of the dressing, the parts remain undisturbed for a week, and sometimes for a fortnight, when the powder and stuffing are removed, with or without syringing the cavities. In the acute cases the discharge from the ear usually ceases after a few days, and the wound over the mastoid is generally closed in from six to eight weeks. In the chronic cases also Professor Macewen prefers the continuance of the dry treatment; but the author has found that, unless the secreting process ceases entirely and early, the continuance of the dry treatment with infrequent dressing is not satisfactory. No doubt if it were always possible to remove every trace of disease, the dry treatment would be the ideal one, but with the conditions existing in the temporal bone in chronic cases this is not always possible. The author has found that, after the first two or three dressings, careful and regular antiseptic cleansing is required for weeks and even for months. A watery solution of carbolic acid or boracic acid is injected once or twice a day through the opening in the mastoid into the external auditory canal, and *vice versa*, while a spirituous solution of carbolic acid or boracic acid, poured in or injected after the syringing, appears to be sometimes beneficial. In some instances, after the use of this for a time, the insufflation of finely powdered boracic acid both into the canal and the artificial opening seems to bring the secreting process to an end. The author has found it necessary in some cases *to discontinue iodoform*, owing to its producing severe eczematous inflammation in the neighbourhood of the wound. The cavities are always stuffed with gauze, and in the outer opening granulation tissue has, in many cases, to be occasionally scraped away with the sharp spoon or touched with chromic acid.

Results of Operation. In regard to the results of operations on the mastoid it may be said that, in acute cases, there are few exceptions to the rule that complete recovery results within a few weeks. In some cases we may shorten the duration of the healing

process by suturing the ends of the wound at the first dressing. When undertaken for the cure of chronic processes in the middle ear and surrounding bone, the results are not so favourable, a period of from three to eighteen months often elapsing before the object of the operation has been attained. When a carious aperture already exists in the cortex of the mastoid, the operation is more simple, and the results are usually more favourable than when undertaken for the cure of intractable purulent disease which has resisted all ordinary forms of treatment, and when no caries or other change is noticed on the surface of the cortex. In some cases it is desirable to allow the opening to remain as a tunnel-shaped passage (Fig. 72) leading into the antrum and attic, "papered" with epithelium and filled with antiseptic gauze.

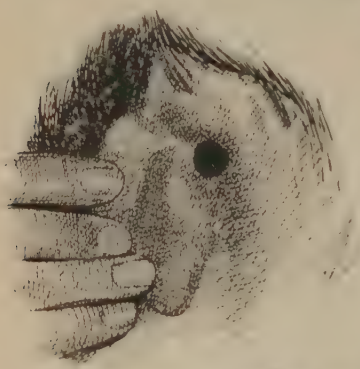

FIG. 72.—Permanent opening leading into antrum after operation.

It is worthy of note that, in certain cases, although the mastoid cells have not been opened into, only a portion of the cortex being removed, apparent advantage has attended the operation.

The following modified operations on the mastoid have been introduced for the cure of chronic purulent processes, especially those centred in the attic and antrum:

Küster's Method of Operating. This operation consists in the removal of the postero-superior wall of the bony canal and the outer wall of the attic. The usual incision in the soft parts is prolonged in a semicircular fashion round the upper part of the auricle. The postero-superior edge of the opening of the osseous canal is exposed. With a small bent spatula (Fig. 65) the periosteal lining of the meatus is separated, and, along with the auricle, is pushed downwards and forwards. The antrum is now opened as already described, and the postero-superior wall of the canal corresponding with the anterior and lower wall of the antrum removed as far as the tympanum with the small gouge or chisel and hammer. To avoid the facial nerve we must keep well up and away from the *lower* portion of the posterior wall of the canal. The outer wall of the attic is then removed and the malleus and incus extracted, as well as granulation tissue and cholesteatomatous masses. In this way the antrum, tympanic cavity, and external canal are converted into one large space, and it is possible to curette the walls, removing all the cario-necrotic collection, granulation tissue, or cholesteatomatous masses which may be found. The separated periosteum is slit, and applied as far as possible to the walls of the cavity. It is recommended that syringing should be sparingly employed after this operation, neither should the dressings be often changed. In many cases the external wound can be sutured at once and the tampons introduced through the canal of the ear.

Stacke's Method of Operating consists in opening the mastoid antrum in the usual way, then removing the postero-superior portion of the inner end of the

osseous canal. The attic is opened into, and the malleus and incus removed if these be found. The periosteum of the canal, corresponding with the gap in the bone, is used for placing against the wall of the cavity in the bony canal, securing in this way an epidermic covering.

Von Bergmann's Method of Operating consists in removing the bony roof of the external canal and outer wall of the attic with a chisel, after which the contents of the attic are scooped out. The posterior wall may be afterwards chiselled away and the antrum opened.

Hessler first opens the antrum and then chisels away the roof of the canal and outer wall of the attic. Subsequent treatment is pretty much on the lines of the ordinary operation for opening the antrum.

XII. EXTRACTION OF THE MALLEUS AND INCUS (OSSICULECTOMY).

This operation is mainly undertaken for the cure of chronic purulent inflammation of the middle ear with perforation of the membrana flaccida, the disease being in the attic, or in the attic and antrum. It should be undertaken only when all ordinary forms of treatment have proved futile. If the hearing is fairly good, as it frequently is in these cases, we must explain to the patient the possibility of the hearing being damaged by the operation; in the event of the opposite ear being deaf this consideration would be very important. The operation is most indicated when the ossicula are in a state of caries; but the absence of this as tested with a probe (Fig. 73) need not deter us, if there are other indications, such as the presence of cholesteatomatous masses. Persistent giddiness and headaches, with other signs of defective health, strengthen the indications for the operation.

Fig. 73.
Attic probe.

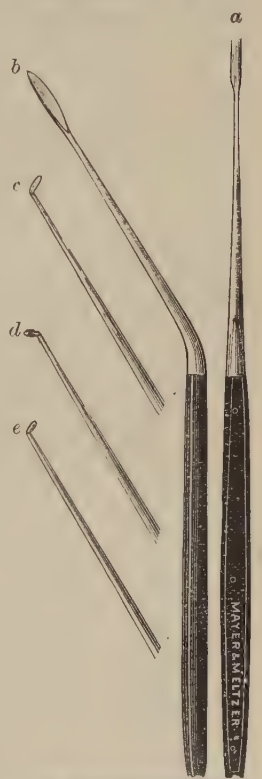

Fig. 74.—Sexton's knives for excision of the ossicles: *a* and *b*, knives for excising membrane; *c*, spade-shaped knife; *d* and *e*, knives for separating the incus from the stapes.

Mode of Operating. The best position is either the lying posture with the head pretty well raised, or the sitting posture with the

head firmly supported. The ear should have been treated previously for some time with antiseptics. The writer has found in several cases that cocaine (10 %) frequently applied during the operation did very well. If this is not sufficient, chloroform may be used with the patient in the lying posture, or ether if in the sitting posture. From each side of the short process of the malleus the membrane is divided with a suitable knife (Fig. 74, *a*) along the periphery so as to include fully the upper half; the membrane is then cut across so as to include the whole of the handle of the malleus. By means of a spade-shaped knife (Fig. 74, *c*) the head of the malleus is separated from its connection, and with suitable forceps (Sexton's) (Fig. 75) the malleus is brought away, the traction being downwards and then outwards. Sometimes it is impossible to remove the incus owing to its being in the antro-tympanic passage out of reach, but it should be removed

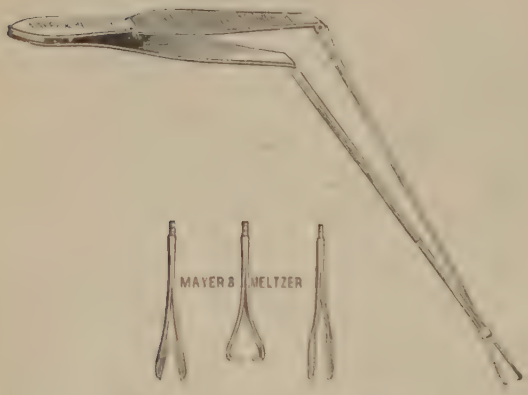

Fig. 75.—Sexton's forceps for extraction of malleus and incus.

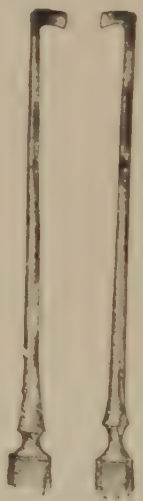

Fig. 76.—Incus hooks. (Politzer.)

if possible with the incus hook (Fig. 76) introduced into the upper tympanic space; the hook is turned backwards and downwards, usually bringing the incus with it. If the incus is still connected to the stapes they should be separated with a suitable knife (Fig. 74, *d* and *e*). The bleeding may be troublesome, and is to be staunched by the frequent application of cotton wool on a cotton-holder. After the removal of the ossicles the attic should, if possible, be stuffed with a narrow strip of iodoform gauze, or a pellet of cotton covered over with boracic acid and attached to a thread. Iodoform and boracic powder (1 to 4) should be insufflated into the canal of the ear. If no untoward symptoms occur, the

ear need not be disturbed for two days; then it should be irrigated, and the stuffing changed. It is often necessary, however, after a week or two, to begin the use of the attic syringe as described at page 69. Although this operation, properly performed, is attended by little danger, rest in bed for a week afterwards is desirable.

In a fair proportion of cases this operation, with the subsequent treatment, brings about a cure of the discharge; but in others it requires to be followed by opening the antrum.

For Non-Purulent Cases. This operation, along with excision of the whole tympanic membrane, is sometimes undertaken for the relief of chronic non-exudative catarrh, progressive in character and attended by painful subjective sounds and giddiness. For this object Lucæ and Sexton are its most ardent advocates. These eminent authorities report somewhat favourably of it, but the general impression amongst aural surgeons is that this operation, for such conditions, is only on its trial, and we have not yet had a sufficient number of results to justify anything like its general adoption. It is certainly not regarded with the same favour as the operation undertaken for the purulent cases just referred to. The tympanic membrane should be completely separated at its peripheral attachment with exception of the malleus connection. The tendon of the tensor tympani, and the articulation of the stapes and the incus are then severed by a suitable knife (Fig. 74, *d* and *e*). By means of forceps (Fig. 75) the malleus is laid hold of at the short process, and pulled downwards and outwards along with, in some cases, the incus. Politzer recommends that an aperture should be previously made with the galvanic cautery; and if, while this is open, the hearing be improved, the operation might then be undertaken.

The Extraction of the Stapes. Stapedectomy has been advocated by Kessel, and the results given by L. Jack, who reports that he has operated with improvement in sixteen cases, are surprisingly good. The experience of others is by no means so favourable, however, and further information is required before its safety or usefulness can be determined.

XIII. PREVENTIVE AND HYGIENIC TREATMENT.

Direct Action of Cold. When there is a predisposition to ear disease, or when some form already exists in the individual, precautions should, if possible, be taken against the direct action of cold water or cold air upon the ear. Cold water, particularly salt water, must never be allowed to pass into the ear, especially if a perforation exists in the tympanic membrane. Even in ordinary washing, in such cases, the ears should be plugged with cotton to

avoid the trickling of water into them. In diving, or in the use of the shower bath, the precautions should be still more minute, cotton plugs soaked in fluid vaseline, or india-rubber ear protectors, being employed (Fig. 77). In sea bathing a water-proof cap should be used in addition. There is probably no popular delusion more common than that splashing or laving cold water upon the ears and sides of the head strengthens the organs. The fact is, the ear is very intolerant of cold, especially in persons who have a hereditary tendency to ear disease, or in whom an ear disease already exists. If such a person be exposed, as in travelling in an open vehicle, to cold wind, especially if accompanied by rain, sleet, or snow, the ears should be carefully protected by a cotton plug, or by a suitable head wrapping, to avoid catarrh, or inflammation of the ear. Of course during mild summer weather, or even in winter if there is no wind, plugging or wrapping up the ear is not desirable, and should not be practised.

Fig. 77.—Macnaughton Jones' aural protectors.

Nasal Catarrh must if possible be avoided, and, when a person with aural weakness is so attacked, he should take measures to get cured as soon as possible (see p. 124).

Exanthematous Diseases. During and immediately after the exanthematous diseases attention should be given to the state of the ear, and, if necessary, prompt treatment employed. In view of the not infrequent absence of subjective symptoms in an acute inflammation of the middle ear occurring during one of the exanthemata, and the serious consequences which may ensue from this disease, it is very desirable that medical men should occasionally inspect the ear, during the course of those diseases which are known to be frequently attended by aural complication, and that they should, on leaving off attendance upon such a case, instruct the patient or friends to report if any symptom, such as a discharge from the ear or defective hearing, shows itself. Timely treatment is of very great importance, and may prevent great mischief to the organ.

Improper Interference. Patients are also to be advised against irritating the ear, either by hard pointed objects, unnecessary or improper syringing, or by the indiscriminate pouring of liquids into the ear.

Loud Noises, either sudden or constant, should be avoided by aural patients. The loud shriek of a railway whistle not infrequently injures an ear even when previously healthy, and, as is well known, boiler-makers and others working amid noisy surroundings nearly always suffer from defective hearing. Such sounds should therefore be carefully avoided by persons with ear disease.

Hygiene. The purity of the air, the cleanliness of the skin, the suitability of the diet, and the healthfulness of the whole surroundings have an influence on the progress of diseases of the ear, especially those which are chronic.

The purity of the air breathed by the patient while sleeping, and absence of dampness and smoke are of importance. The impure air breathed in school-rooms, offices, and worshops, in some instances loaded with mechanical or chemical irritants, is very likely to maintain catarrhal processes in the nose, throat, and middle ear. Out-door exercise in suitable weather with proper precautions, especially if the air is not only pure and fresh but also dry, conduces to a healthy state of these mucous membranes.

In some cases of muco-serous catarrh, when local treatment proves unsuccessful, a residence of two or three months in the country, especially in a mountain or upland district, has proved most satisfactory in maintaining a permanent state of improvement. In all cases a change of air from town to country is a powerful aid to local treatment. In chronic dry catarrh, while change of air has not usually so beneficial an influence upon the ear, it is very often advantageous, especially with children. A mild, dry, equable climate probably acts by diminishing the tendency to nasal and pharyngeal catarrh.

Baths of warm or luke-warm salt water, repeated every second day, have often a useful effect upon the catarrhal process in the ear, when thorough friction of the skin is employed after each bath. Sea bathing or cold water bathing is sometimes beneficial in chronic dry catarrh, where every precaution is adopted to keep the water out of the ear. Judiciously employed, it protects the system against catarrhal attacks; but, if the dulness of hearing or the tinnitus becomes aggravated, the bathing must be abandoned.

Tobacco—Alcohol—Medicines. Excessive use of tobacco or alcoholic drinks exercises a deleterious influence in inflammatory or catarrhal affections, not only inducing a hyperæmic condition of the ear, but also tending to produce a state of chronic pharyngitis. These luxuries must therefore be employed in very great moderation. Quinine or salicin should also be used with great caution, or avoided altogether, when an ear disease already exists.

CHAPTER V.

AFFECTIONS OF THE NOSE AND THROAT IN RELATION TO THE EAR.

THE mucous membrane lining the nasal passages and pharynx is frequently the place of origin of ear diseases, and its morbid conditions have an important influence on the course and issue of affections of the middle ear. In our modes of examination and in therapeutic measures, therefore, attention must always be directed to this region.

I. MODES OF EXAMINATION.

(A) *EXAMINATION OF THE NASAL PASSAGES FROM THE FRONT —ANTERIOR RHINOSCOPY.*

Nasal Specula. We require a concave reflector and a proper speculum. Many varieties of nasal specula are used. A large-sized

FIG. 78.—Anterior rhinoscopy.

aural speculum (Gruber's) may sometimes suffice to dilate the nostrils. A bivalve speculum, such as Roth's (Fig. 79), is however more

suitable. It is introduced easily when closed; and by pressure upon the handles the leaves are separated, and the yielding walls of the nasal entrance dilated. The speculum is introduced with the blades closed, the handles upwards and supported with the thumb and index finger of the left hand. The screw which opens the blades

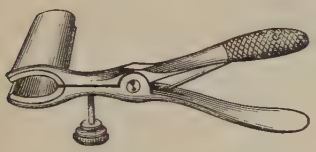

Fig. 79.—Roth's speculum.

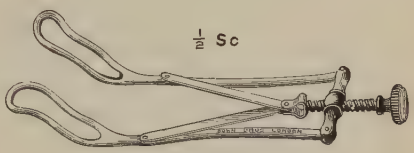

Fig. 80.—Frænkel's speculum.

is worked with the right hand. In this way, if good light is reflected into the nasal passage, we may in favourable cases inspect it throughout its whole length. Frænkel's (Fig. 80), Thudicum's (Fig. 81), and other forms of specula are preferred by some. Zaufal has invented a tubular speculum, which is introduced like a Eustachian catheter through the inferior meatus of the nose, as far as the upper pharyngeal cavity. When the nasal passage is of sufficient width to allow of the introduction of such a tube, we may see, with good reflected light or electric lamp (Fig. 82), the movements of the soft palate and of the lips of the Eustachian tube during phonation or swallowing. Cresswell Baber, of Brighton, has devised a self-

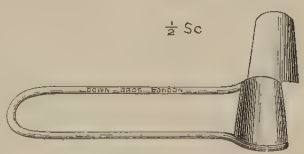

Fig. 81.—Thudicum's spring nasal speculum.

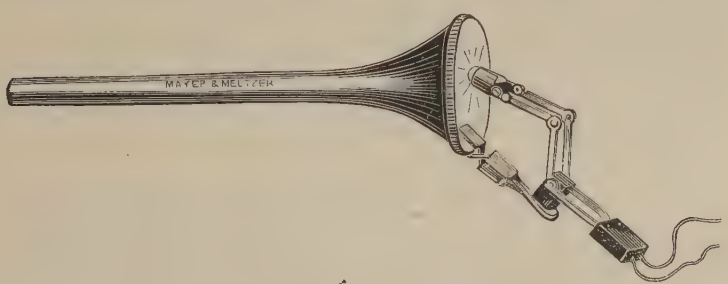

Fig. 82.—Zaufal's tubular speculum.

retaining nasal speculum (Fig. 83) for dilating the anterior nares, made of two wire hooks united by an elastic band provided with a buckle, for passing and securing round the patient's head. This contrivance is very convenient when both hands are required for operation.

Cocaine. The application of a 10 per cent. solution of cocaine, by means of cotton wool or a spray, to the mucous membrane, very

FIG. 83.—Baber's self-retaining nasal speculum.

much facilitates the examination by diminishing the sensitiveness, and by widening the passage through contraction of the swollen erectile tissue on the inferior turbinated bone. In this way cocaine has been of enormous service in the examination and treatment of the nose.

Parts seen by Anterior Rhinoscopy. As seen by anterior rhinoscopy, the mucous membrane of the inferior spongy body has usually a bright red or pink colour, and is seen inside the nostril as a rounded swelling, projecting from the outer wall. In many cases a deflection of the septum, or a bony or cartilaginous projection upon it, or an enlarged inferior spongy body limits our view to the anterior parts. Between the inferior spongy body and the floor of the nasal passage we see the inferior meatus, through which the catheter is passed in catheterization of the Eustachian tube (Fig. 14). This and the floor of the nose are best seen if the patient bends the head forwards during the examination. If the meatus is wide, and especially if cocaine has been previously used, we may see through it, during swallowing, the elevation of the soft palate and the bulging up of the *levator palati* muscle. The inferior meatus might almost be regarded as a continuation of the Eustachian tube. In some cases of great swelling or hypertrophy of the mucous membrane covering the inferior spongy bone or the floor, the passage may be quite filled up. Between the middle and inferior spongy bones we see the middle meatus. In extreme cases of catarrhal swelling of the mucous covering of the middle spongy bone, the pendulous swelling of the mucous membrane may be mistaken for a nasal polypus. The middle spongy body is seen best when the patient throws his head back. It appears higher up and further back than the inferior. It is also thinner and paler, and frequently approaches very near the septum.

(B) *EXAMINATION OF THE NASO-PHARYNX.*

Inspection of the Naso-Pharynx—Posterior Rhinoscopy (Fig. 84). A forehead reflector is used as in anterior rhinoscopy, and a small mirror is introduced into the throat with the reflecting surface upwards. Perhaps the best form of mirror, however, is that known as Michel's (Fig. 85), which has a mechanism by which, on pressure upon a lever, the angle of the mirror may be altered as desired. The tongue requires to be well pressed down with a bent spatula, while a palate hook may sometimes be necessary to pull the uvula upwards and forwards out of the way. White's self-retaining palate

hook (Fig. 86) introduced by Baber is the best. It has a movable clip which presses on the upper lip and supports the instrument.

Fig. 84.—Examination by posterior rhinoscopy.

It is well to apply firm pressure to the soft palate; and a solution of cocaine should be applied to the upper surface before the palate

Fig. 85.—Michel's post-nasal mirror.

Fig. 86.—White's self-retaining palate retractor.

hook is used. While the mirror, previously warmed slightly over the lamp, is in the pharynx to one side of the uvula, without touching the parts, the patient's head should be inclined slightly forwards, and he should pronounce a nasal syllable as the French "*on*," which

tends to increase the space between the soft palate and the posterior wall of the pharynx. Sniffing or attempting to breathe through the nose is also useful.

Image by Posterior Rhinoscopy. In favourable cases the image seen in the mirror (Fig. 87), when its reflecting surface is directed upwards and forwards, includes (1) the posterior edge of the nasal septum in the centre, of a pale pinkish colour, and (2) the posterior ends of the three spongy bones projecting from the outer walls of the posterior nares. The superior is the smallest, and appears as a small ledge-shaped projection; the middle one is usually the largest and most distinct, and forms an oblong protuberance of a grayish or sometimes bluish colour; while the inferior is generally only seen in its upper part, a portion of it being concealed by the soft palate, and appearing as a grayish rounded projection. The inferior spongy body may, when its mucous membrane is very much swollen, encroach upon the pharyngeal mouth of the Eustachian tube.

FIG. 87. Posterior rhinoscopic view, as seen with the mirror in the ordinary position. *a*, Posterior surface of uvula; *b*, uvula cushion; *c*, *c*, posterior margin of palate; *d*, *d*, levator cushions; *e*, septum nasi; *f*, *f*, swellings on the sides of septum; *g*, *g*, choanæ or posterior nares; *h*, *h*, inferior turbinated bodies; *i*, *i*, middle turbinated bodies; *j*, *j*, Eustachian openings, more strictly the depressions leading to them; *k*, *k*, Eustachian cushions; *l*, *l*, salpingo-pharyngeal folds; *m*, *m*, salpingo-palatine folds; *n*, *n*, position of upper part of Rosenmüller's fossæ; *o*, *o*, posterior tubal sulci. (Cresswell Baber.)

If the mirror be now directed somewhat laterally we see the *pharyngeal mouth of the Eustachian tube*. This is found a little behind, and somewhat higher than, the inferior spongy body, above the upper surface of the soft palate. It has generally a triangular form, the base being directed forwards and the apex backwards, and has usually a whitish colour. It is bounded above and behind by a rounded projection, much more marked in some persons than in others. Behind the projection is seen the *fossa of Rosenmüller*. By changing the angle of the mirror so that the reflecting surface may be directed as nearly as possible upwards, the image of the roof and a part of the posterior wall of the upper pharynx is seen.

Pathological Appearances in the Naso-Pharynx. The most common pathological condition in connection with ear disease, especially in children, found in the naso-pharynx is hypertrophied glandular tissue, the so-called adenoid vegetations or post-nasal growths. These spring from thick glandular tissue, embedded in the mucous membrane and known as the pharyngeal tonsil, which becomes much hypertrophied and the seat of outgrowths, which may in some cases fill the upper pharyngeal cavity and appear as tongue-shaped projections from the roof and posterior wall. We may also find the mucous membrane much congested, swollen, and covered by catarrhal secretion, or it may be

studded with granular projections, especially when there is granular pharyngitis. Ulcerations, cicatrices, or adhesions are less common.

Digital Examination of the Naso-Pharynx. This mode of examination often yields valuable information, and should be employed especially when posterior rhinoscopy is impracticable, as in young children. The patient should be seated, and, while his head is steadied with the left hand, the right index finger (the first phalanx of which should be protected with a piece of thick india-rubber tubing) is introduced as far as the posterior wall of the pharynx. The tip of the finger is then passed up behind the uvula, taking care not to push the uvula before it. The muscular spasm which takes place usually passes off when the point of the finger is fairly in the upper pharyngeal cavity. During the examination the patient should take full and regular inspirations through the nose. By moving the finger in the proper directions we can in most persons gain a pretty clear notion of the condition of the upper surface of the soft palate, of the posterior edge of the nasal septum, of the posterior end of the inferior spongy bone, of the mouth of the Eustachian tube, of Rosenmüller's fossa, and of the vault of the pharynx. In a normal condition the mucous membrane lining those parts should be firm and smooth.

(C) *EXAMINATION OF THE LOWER PHARYNGEAL CAVITY.*

The walls of this cavity are easily examined through the widely open mouth, either by means of reflected light from a mirror on the forehead, or by means of artificial light or daylight arranged so that it shall pass directly into the open mouth. In most persons

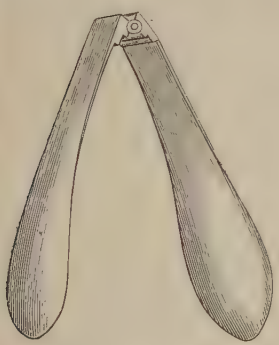

Fig. 88.—Tongue depressor.

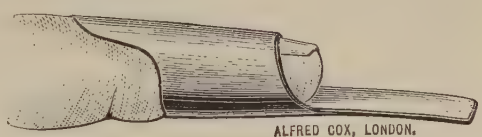

Fig. 89.—Baber's thimble tongue depressor.

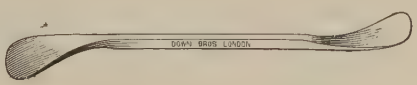

Fig. 90.—Tongue depressor for children.

it is necessary to press the tongue downwards upon the floor of the mouth. The flat handle of a spoon is generally sufficient for this purpose, but a tongue depressor is frequently used. A convenient form consists of a double spatula (Fig. 88) made of

vulcanite or metal, the two pieces of which are connected together by a hinge joint. The thimble depressor of Baber (Fig. 89), or that depicted in Fig. 90, is particularly suitable for children. In some persons, the attempt to depress the tongue sets up spasmodic contraction of the muscles of the pharynx and troublesome retching. In these cases the use of the finger to depress the tongue may be better tolerated; or we may be able, without attempting to depress the tongue, to get a view of the pharynx while the person takes a full inspiration. In a resisting child, closing the nose with the fingers will ensure the opening of the mouth. The examination is generally facilitated by the patient breathing deeply through the mouth or pronouncing the syllable *ah*, during which the soft palate is raised.

In addition to the posterior part of the upper surface of the tongue, we see the movable curtain of the soft palate, the uvula, the posterior wall of the pharynx or mucous membrane covering the pre-vertebral structures, and on each side the anterior and posterior pillars of the fauces with the tonsil in the niche between them. The normal colour of these parts is a rosy pink, but considerable variety of tint is compatible with a healthy state. When the tongue is well depressed, especially in children, the upper part of the epiglottis is sometimes visible.

Pathological Changes in the Pharynx. As the result of catarrhal or inflammatory processes, the condition of the various parts of the pharynx may be very much changed from the normal. In their relation to diseases of the ear the *chronic* catarrhal or inflammatory changes most deserve our attention. It is a mistake to judge of the condition of the upper pharyngeal space from the appearance of the lower. The latter may appear almost normal, and yet the former may be involved in very considerable morbid changes. The lining membrane of the pharynx is not unfrequently swollen or thickened, of a bluish red colour, and very intolerant of touch, and the divisions between the various parts are much less marked. The uvula is often elongated and œdematous at its tip, or, on the other hand, it may be extremely short and puckered. It is sometimes broad and sometimes thin and pointed. The soft palate has frequently a thick, red appearance. The uvula may deviate to one side, especially during contraction of the palate muscles, with a smooth inactive state of the soft palate on the side from which the uvula deviates. The tonsils are frequently enlarged, especially in childhood, when they may almost meet in the middle line. On the other hand, they may be so atrophied as to have nearly disappeared. We may find numbers of red or reddish-grey elevations on the posterior wall of the pharynx due to swollen or hypertrophied follicles—the so-called follicular or granular pharyngitis. The intervening mucous membrane may be pale and thin or slightly red and swollen. Sometimes we see an elongated, reddish, spongy-looking elevation on each side passing up from the posterior pillars of the fauces towards the mouths of the Eustachian tubes. At other times we find the mucous membrane smooth, thin,

red, and glazed; either dry (probably from atrophy of the follicular glands), or covered with greenish, laminated masses of secretion, evidently, in part at least, coming down from above. Connected with this state there may be great anæsthesia of the mucous membrane, so that free touching with the mirror is tolerated without any muscular response. Lastly, in the atrophic stage of chronic catarrh we find the mucous membrane whitish and so extremely thinned that the constrictor muscles lying in front of the vertebræ may be seen shining through. In this condition varicose veins may traverse the mucous membrane. Dilated vessels are not uncommon on the posterior wall of the pharynx.

II. DISEASES OF THE NOSE AND THROAT.

The chief morbid conditions of the nasal and pharyngeal mucous membrane which exercise an influence upon the middle ear are:

(*a*) Acute rhinitis.
(*b*) Chronic rhinitis.
(*c*) Adenoid vegetations in the naso-pharynx.
(*d*) Acute and chronic pharyngitis.

(A) *ACUTE RHINITIS (COLD IN THE HEAD).*

Symptoms of Cold in the Head. This is a common cause of middle ear disease. The symptoms are familiar to every one from personal experience. The mucous membrane of the nose and naso-pharynx is in a state of hyperæmia, swelling, and hypersecretion, the morbid process frequently extending to the sinuses and canals communicating with the nasal passages. The secretion is at first thin and serous, afterwards becoming thicker and more viscid. There is a sense of "stuffing" or obstruction in the nose. There are also attacks of sneezing, with occasionally frontal headache and tenderness over the superior maxilla. The tone of the voice becomes changed, having a so-called nasal character. When the pharyngeal mouth of the Eustachian tube is involved in the swelling and hypersecretion, there is a sense of fulness and ringing in the ear with some impairment of hearing. The symptoms usually pass off in from a few days to two weeks. In certain states of the constitution, however, such as the strumous diathesis, or when a markedly catarrhal tendency exists in the individual, the acute catarrh may pass into the chronic form, which may continue with varying degrees of intensity for years or even during a life-time.

Special Forms. We must note, as especially bearing upon the welfare of the ear, the forms of acute rhinitis attending measles, scarlet fever, and diphtheria. In the two latter conditions very serious complications in the ear may arise from extension of the inflammation in the naso-pharynx, along with the specific organisms of these diseases, to the cavities of the middle ear. The combination of scarlet fever and diphtheria is especially dangerous to the ear.

(B) *CHRONIC RHINITIS (CHRONIC COLD IN THE HEAD).*

A large number of persons afflicted with ear disease or deafness are the subjects of some form of chronic rhinitis, the existence of which, especially of the post-nasal variety, is a constant menace to the ear. It frequently arises out of repeated attacks of acute rhinitis, and is often connected with a hereditary catarrhal tendency. In chronic rhinitis we have, in addition to dilated vessels and parenchymatous serous exudation, round cell infiltration of the mucous membrane and sub-mucous tissue, changing in time into connective tissue; while implication of the bony framework of the nose is not uncommon. There are several varieties of chronic rhinitis.

Hypertrophic Variety. The glandular tissue embedded in the mucous membrane, especially in the roof of the pharynx and in the posterior wall, frequently becomes hypertrophied, and the walls are studded with enlarged follicles—this condition being termed granular or follicular pharyngitis. Small cysts filled with a colloid fluid may form in Rosenmüller's fossa; the contents of these after a time escape and the walls coalesce, leaving a number of fine fibres bridging the fossa. The Eustachian prominence also is often much enlarged. In children hypertrophy of the glandular tissue on the roof and posterior wall is very common, constituting post-nasal growths or adenoid vegetations (see p. 120); the atrophied remains of these may often be seen as rough projections on the roof of the naso-pharynx.

The *inferior spongy body* may be enlarged to such an extent as to be in contact with the septum and fill up the inferior meatus, while, behind, it may project into the upper pharyngeal cavity as a large, round, frequently greyish white swelling, very likely to be mistaken for a tumour, sometimes extending to the mouth of the Eustachian tube. This enlargement may simply be due to distension of the erectile tissue which lies under the mucous membrane, or to actual hypertrophy. In the first case the action of cocaine in causing the swollen tissue to shrink is much more marked than in real hypertrophy. The mucous membrane over the *middle and superior spongy bones* may also become much hypertrophied, forming flap-shaped masses which may be readily mistaken for polypi. The red hypertrophied mucous membrane is distinguished from genuine polypi by the grey appearance of the latter, which are also readily moved and displaced by a probe (Fig. 91). *Nasal polypi* frequently form in connection with chronic rhinitis and their presence tends to keep up the condition of rhinitis. Polypi having their origin in the nasal passages sometimes project into the upper pharyngeal cavity, and may even be seen in the throat below the posterior edge of

the soft palate. *Exostosis* and *enchondrosis* of the nasal septum, forming horizontal ridges or spurs, which sometimes almost occlude the air-way, are frequently met with and are often the consequences

Fig. 91.—Nasal probe.

Fig. 92.—Œdema of the septum of the nose.

of chronic rhinitis. These may be distinguished from a deflected septum by the fact that in the latter there is a corresponding concavity on the opposite side. Great œdematous swelling on both sides of the septum, closing the passages and entirely obstructing nasal breathing, may be due to acute enchondritis, which may cause flattening of the nose (Fig. 92).

Atrophic Form. The catarrhal process may lead to atrophy of the mucous membrane. Over the posterior wall of the lower pharynx the mucous membrane is then seen to be thin, smooth, whitish, and often dry and glazed; while in the nasal passages the spongy bodies, especially the inferior, become very small, so as to be sometimes scarcely perceptible, and the space between the septum and the outer wall becomes so widened that we may, with good light and an ordinary nasal speculum, see distinctly the posterior wall of the naso-pharynx and the action of the palate muscles in swallowing. This condition is termed *atrophic rhinitis* or *ozæna*. It has been asserted that the fœtor characteristic of ozæna is due to this wide

condition of the nasal passages. The expired air, it is said, meeting with less resistance from the walls of the passage, has not the same effect of sweeping before it the secretions of the nose, which as a consequence lie stagnant and decompose. A special micro-organism has been found by Löwenberg to be associated with ozena.

Syphilitic and Strumous Varieties. Ulcerative processes in the mucous membrane and disease of the osseous and cartilaginous walls are met with most commonly in syphilitic affections, and less frequently in persons of strumous constitution. Portions of necrosed bone from the septum, spongy bones, or floor of the nasal passage may, in these conditions, exfoliate. As a result of syphilitic ulceration, we not unfrequently find whitish, thick, and tough radiating cicatrices in the pharynx, and sometimes the Eustachian tubes are closed by the cicatricial tissue. The soft palate may be partially destroyed, or there may be a perforation in the floor of the nose. The osseous septum is also frequently partially destroyed, so as to lead to the deformity of sunken nasal bones. Perforation of the cartilaginous part of the septum is generally due to the strumous form of the disease, and is not followed by the deformity.

SYMPTOMS AND CONSEQUENCES OF CHRONIC RHINITIS.

The Chief Symptoms and Consequences of chronic rhinitis are the following: Changes in the character and quantity of the nasal secretion; nasal obstruction, with its results (mouth breathing, changes in the voice, noisy breathing, defective sense of smell, caries of teeth); pain in the head; asthma; eczema of the nostrils; disturbance of the general health; *disease in the middle ear*.

Secretion in Chronic Rhinitis. The quantity and the character of the secretion in chronic rhinitis present great varieties. It may be very scanty, especially when the disease is *post-nasal* in situation, and the sensation is more that of dry obstruction in the nose, or of a stuffed head. At other times there is a feeling as of something requiring to be brought up, impelling the person to make great and noisy efforts to bring up phlegm from the throat. These efforts are probably successful in expelling small pellets of tough and adhesive mucus, which, if the person resides in a city, have usually a dark colour. This inclination to "hawk" is usually most felt in the morning. In some persons, especially those who habitually indulge too freely in alcoholic stimulants, these "hawking" efforts excite, particularly in the morning after rising from bed, a spasmodic action of the pharyngeal muscles, causing retching and even vomiting. After swallowing hot liquid the mucus loosens, and is brought up more easily. The secretion

from the nose may, on the other hand, be thin and copious (*rhinorrhœa*), or it may be simply mucous or muco-purulent. If the discharge is limited to one nasal passage, and distinctly purulent in character, having, it may be, a very offensive smell of which the *patient is conscious*, its source is probably the *antrum of Highmore*. Inspection will then show polypoid excrescences in the middle meatus, at the orifice of the canal leading from the antrum to the nose. Pus will also be seen in that situation, which, on being wiped away, will be almost immediately followed by further purulent oozing. The pus more rarely comes from the frontal and ethmoidal sinuses. In the atrophic form of chronic rhinitis (*ozæna*), the secretions have an extremely offensive odour. The sense of smell being impaired, the *patient is seldom conscious*, unless informed by others, of these offensive exhalations. In this condition we may find dried greenish crusts, or even membranous portions, adhering so closely to the mucous membrane as to render it difficult to wash them completely away. After using the Eustachian catheter we sometimes find on the catheter greenish grey masses, which have evidently come from the naso-pharynx. *Bloody sputa*, which may resemble pneumonic expectoration, sometimes come from the congested vessels in the post-nasal cavity, and, when such sputa are brought up and no pulmonary cause is found to exist, the upper pharynx should be carefully examined. Secretion which may be tinged with blood, coming from the anterior nares or mouth, is occasionally found in the morning staining the pillow.

Nasal Obstruction and its Consequences. The partial or complete obstruction of the nasal passages, or of the naso-pharynx, attending the swelling, thickening, or hypertrophy of the mucous membrane or glandular tissue, interferes with due nasal breathing; and the breathing may become in great part or altogether *oral*, a peculiarity which sometimes continues as a habit long after the actual obstruction has passed away. The obstruction may vary from time to time with the varying degree of the catarrhal swelling. The change produced in the physiognomy of a child constrained to breathe habitually through the open mouth, is often very characteristic (Fig. 93). In marked cases the mouth is open, the lower jaw hangs down, the nose is pinched-looking, the nostrils are fallen in, the nasal bones sometimes appear to bulge from contrast, while the expression of the countenance is vacant and dull, and if defective hearing exists the manner is inattentive. *The voice* becomes changed in character and in strength from the diminution of the resonance chambers of the nasal passages and naso-pharynx. It is weak in the higher tones, and the pronunciation of *m* and *n* sounds like *b* and *d*. For example, the word "common" is pronounced like "cobbod," "Moses" like "boses," "nose" like "doze."

The laryngeal voice is also sometimes muffled, thick, and otherwise impaired, especially the singing voice, which soon becomes weak, hoarse, or husky after slight exertion. This may be due, however, to the extension of the catarrhal process to the larynx.

FIG. 93.—Facial aspect in deafness associated with post-nasal growths.

Snoring or loud, almost stertorous, breathing is also usually an accompaniment of nasal obstruction, and in bad cases, when due to adenoid vegetations, the child may spring up in alarm during sleep from the impeded nasal breathing. This embarrassed breathing is frequently aggravated by the presence of enlarged tonsils. While impairment or loss of the sense of smell (*anosmia*) is usually due to the changes produced by the catarrhal process upon the terminal structures of the olfactory nerve, there is no doubt that when the function of the nerve is in abeyance for a long time, through the absence of nasal breathing, there may result permanent injury to the sense of smell.

Persons who breathe habitually by the mouth during sleep usually have a *dry mouth* in the morning, and they do not feel comfortable until they gargle the throat or eat a warm breakfast. It is said that caries of the teeth may sometimes in these cases result from the dry mouth.

The General Health may Suffer from Nasal Obstruction. It is alleged that in children, long-continued nasal obstruction may lead to defective chest development. Further, the walls of the nasal passages present extensive, warm, and moist surfaces, which form a kind of natural respirator, warming, moistening, and purifying the inspired air before it passes over the vocal apparatus and into the lungs. The dust and other irritating particles in the air are partly detained on the irregular and projecting surfaces of the spongy bodies. Hence nasal

breathing is favourable to a healthy condition not only of the vocal but also of the respiratory organs. When a child regularly inspires into its lungs over a period of years, air, which by passing through the mouth is colder, drier, and more impure than it should be, we might expect an injurious influence upon the lungs; and there is a suspicion that a predisposition to tubercular disease may in this way be generated. We find by experience that the health of a child in such a condition is often manifestly improved after the obstructions have been removed. It is also probable that the general health may suffer in ozæna by the constant inhalation of the gases of decomposition or by the injurious effects on the digestive organs caused by the swallowing of the offensive secretion. *In the sucking infant* obstruction of the nasal passages may have a specially serious effect on the health and comfort of the child. An infant breathes, of course, chiefly and most comfortably through the nose, hence such an obstruction renders the act of sucking difficult, or even impossible. The refusal to take the breast, from impeded nasal breathing, is probably sometimes confounded with some other and more important ailment. The great discomfort arising from the difficult nasal breathing also prevents sleep, and the child passes restless nights. It is clear that, if these two great essentials to infant life—sucking and sleeping—are interfered with, injury to the health must soon ensue.

Disease of the Middle Ear, manifesting itself by disturbance of hearing or purulent discharge, often arises out of the various forms of chronic rhinitis. The ways in which the ear is involved in these cases have been already described (see p. 54).

Pain in the Head is not unfrequently complained of over the frontal and maxillary sinuses, probably owing to extension of the inflammatory process to these cavities. Pain, evidently of a reflex character, may be experienced in other parts of the head, as in the temple or in the occipital region. These pains, generally called neuralgia, are probably due to pressure exerted by the thickened tissue upon the numerous nerve fibrils of the trigeminus ramifying in the mucous membrane, and affecting by sympathy adjoining branches of the same nerve trunk.

Paroxysmal Sneezing, or so-called *hay fever*, is sometimes the chief complaint in chronic rhinitis. This symptom, however, may exist without any objective sign of rhinitis, being then a neurosis of the nasal mucous membrane.

Asthmatic Attacks have, no doubt, occasionally their origin in a reflex action excited by chronic swelling or thickening of the nasal mucous membrane. False croup or *spasm of the glottis* is said to be sometimes excited by the secretion dropping from the naso-pharynx into the larynx.

Eczema of the Nostrils. In chronic rhinitis slight eczematous conditions sometimes arise just inside the nostrils. Crusts may in this way form which plug up the nostrils, and, in infants, lead to serious obstruction to nasal breathing; or the irritation may give rise to erythema in the neighbouring skin, and sometimes even to erysipelas.

(C) *POST-NASAL ADENOID GROWTHS.*

Syn.—Adenoid Vegetations in the Naso-Pharynx.

These growths are most important causes of middle ear deafness, and their removal is one of the most useful remedial measures employed in the catarrhal deafness of early life.

The discovery by William Meyer in 1860 of these growths and their bearing upon disease of the middle ear may be said to mark an epoch in the history of this department of medicine. Meyer's discovery was first laid before the profession in a paper to the Royal Medical and Chirurgical Society in 1869. The subject was again brought prominently forward in a discussion at the International Medical Congress, London, 1881, at which Meyer took part. Guye of Amsterdam and Löwenberg of Paris have also done good service by their early and valuable writings in connection with this subject.

Pathology of Post-Nasal Growths. There is a mass of glandular tissue, called the *pharyngeal tonsil*, found chiefly on the roof of the naso-pharynx, but extending upon the posterior and lateral walls. Adenoid vegetations are the result of hypertrophy of this tissue; and microscopically they consist of mucous glands and lymphoid tissue with closed follicles. They appear in the form either of tongue-shaped, cylindrical, or flat excrescences chiefly on the postero-superior walls, but they may extend to the posterior nares, and be seen as pendulous masses hanging from the roof behind the choanæ, which they veil at the upper part (Fig. 94). It is obvious that the small naso-pharynx of a child will be easily occluded by them. The growths are in some cases soft, pliable, and easily brought away; in other cases they are firm in texture, and have a strong attachment. There is frequently associated with them granular pharyngitis, with enlarged tonsils and chronic hypertrophic rhinitis. In connection with, and dependent upon, this condition, the ear may be variously affected: most frequently simple exudative catarrh of the middle ear is produced, but sometimes we find purulent disease, with all the possible consequences, resulting from, or maintained by post-nasal growths.

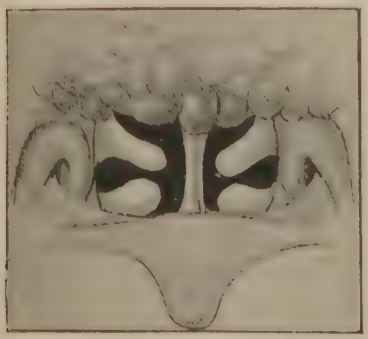

Fig. 94.—Post-nasal growths as seen by posterior rhinoscopy.

Causes of Post-Nasal Growths. They belong pre-eminently to early life and are often hereditary, several members of one family

being sometimes affected with them. Parents sometimes say, "I breathe with the mouth open myself," and on examining the naso-pharynx evidence of past vegetations will often be seen. From the accounts given by parents one is disposed to think that the growths are sometimes congenital. Just as faucial tonsils are prone to hypertrophy in childhood, so apparently is the glandular tissue in the roof of the pharynx. Measles, scarlet fever, and colds in the head, probably by exciting catarrh of the upper pharyngeal cavity, may lead to these growths. *Age* seems an important factor in their production, for they are rarely met with in persons over twenty-five, although remnants, in the form of irregular thickenings of the mucous membrane, are found in adult age, causing a tendency to post-nasal catarrh. Between three and fifteen years seems to be the period of life in which they are most common, and they probably never develop after puberty. *They tend to atrophy, and disappear spontaneously when adult age is reached.* A damp, cold climate is favourable to their production, although they occur in all climates. Some believe them to be connected with the rheumatic diathesis and others with the strumous.

Symptoms of Post-Nasal Growths. The most striking of the symptoms are due to obstructed nasal breathing (see p. 117). From this cause the child is sometimes unable to blow the nose. The mouth is in most cases habitually open at night and often at other times. Noisy breathing is common during the day, especially when eating; while snoring is also common at night, with dribbling from the mouth. It is to be noted, however, that these growths may exist and cause middle ear disease without much, if any, nasal obstruction. In many cases we find, on examination by posterior rhinoscopy, that there is quite sufficient air-way at the posterior nares, indeed the growths rarely extend further down than a third of the choanæ. On the other hand there may be very marked nasal obstruction and pronounced growths in the naso-pharynx with no affection of the hearing. Probably in about thirty per cent. of the cases there is implication of the ear. The defective nose breathing may be due in many cases to the turgescence or hypertrophy of the turbinals rather than to the actual mechanical impediments offered by the adenoids, and thus with every nasal catarrh the impeded nasal breathing becomes for the time worse. The defective hearing is often very marked, and there may also be a discharge from the ear. Stammering and stuttering have been attributed to the presence of adenoids. Guye of Amsterdam believes that children, as a result of these growths, are deficient in mental application or power of continuous attention, and he thinks this is due to obstruction in the lymphatic channels in their course from the brain

through the nasal mucous membrane. He terms this condition *aprosexia* (*a*, privative; *prosexia*, attention). The defective hearing, however, may in many cases account for these symptoms, as shown in the author's paper on "The Hearing of School Children." Defective health may no doubt result from adenoids; for the impediment to nasal breathing and the open mouth are apt to be attended by tossing about in bed, nightmare, and imperfect aeration of the blood, sufficient to impair the general health. It is surmised, and probably with truth, that in a child suffering from post-nasal growths there is greater susceptibility to the infection of scarlet fever or diphtheria, while these diseases are also apt to assume a more severe form.

In marked cases we find that in syringing fluid into the one nostril it cannot be made to flow out of the other. There is usually a copious secretion from the growths, and the neighbouring nasal and pharyngeal mucous membrane is generally in a catarrhal condition. On account of the vascularity of these vegetations a little blood may sometimes escape from the nose, and bloody mucus is occasionally expectorated from the throat. A more deeply arched palate is said to be sometimes associated with them.

Diagnosis of Post-Nasal Growths. While from such symptoms, especially the defective nasal breathing, the open mouth, the compressed nostrils, the snoring and even embarrassed breathing during sleep, and the sluggish intellectual powers, we should suspect the existence of adenoid vegetations in the naso-pharynx, certainty can be attained only by physical examination. By the introduction of the finger through the mouth into the naso-pharynx the sensation of a thick soft cushion or soft masses hanging down from the roof is experienced. Posterior rhinoscopy, where possible, is to be preferred to digital examination, as being less disagreeable to the patient; but in children we generally have to rely upon digital examination (see p. 111), and, as Meyer remarks, the practised finger will reveal with sufficient clearness, the number, situation, size, shape, consistence, and vascularity of the growths. The finger after withdrawal is usually tinged with blood.

(D) *DISEASES OF THE LOWER PHARYNX.*

The various diseases of the lower pharynx have not so direct an influence in producing affections of the ear as those of the naso-pharynx and nasal passages. Those which are most apt to injuriously affect the ear are: (1) simple acute pharyngitis, (2) chronic pharyngitis, (3) acute tonsillitis, (4) chronic tonsillitis with hypertrophy, (5) syphilis of the pharynx. The first two are frequently associated with similar inflammatory conditions of the naso-pharynx, through which

the middle ear may be involved; or they may, by causing thickening of the mucous membrane of the soft palate, injure the tube muscles lying underneath. The affections of the tonsils may either excite severe pain in the ear through nerve connection, or, when enlarged, they may press up upon the floor or entrance of the Eustachian tube, and thus disturb its functions. They may also impede clear nasal breathing, although the adenoid vegetations, with which they are often associated in childhood, are more likely to be the cause of this. The conditions of the throat associated with diphtheria and scarlet fever often lead to mischief in the ear through the naso-pharynx (see p. 53).

CHAPTER VI.

THE TREATMENT OF THE NOSE AND THROAT IN RELATION TO THE EAR.

For a description of the nature and symptoms of the various affections of the nose and throat, which tend to involve the ear, see the previous chapter.

I. TREATMENT OF ACUTE RHINITIS OR COLD IN THE HEAD.

Preventive Treatment. When there is a tendency to frequent attacks of acute rhinitis, especially if these are accompanied by any disturbance in the ear, preventive measures should be used. These include the avoidance of sudden and extreme changes of temperature, of damp cold air, of exposing the uncovered head to the cold open air, of excessive indulgence in alcohol or smoking. The growth of a moustache has sometimes a good prophylactic effect. Sponging of the body with cold or tepid salt water followed by brisk friction: plenty of fresh open air during mild and dry weather; residence in the country, especially in a mountainous region or in a wooded district; these tend to invigorate the general health, and probably lessen the liability to attacks of catarrh. If the tendency is based upon the gouty or rheumatic diathesis, appropriate remedies may be required, such as a course of Carlsbad salts, or of salicylate of soda. The treatment of the chronic conditions (see p. 126), if such exist, is of great service.

Local Treatment. During the attack steam or dry inhalations to the nasal passages tend to relieve the unpleasant sensations. For *steam inhalations*, india-rubber nasal pieces placed on the mouth-piece of an ordinary or Whistler's inhaler are required. The simple vapour of water is useful in softening hardened secretion, or when there is a dry condition of the mucous membrane. The addition, however, of various medicaments will prove useful, such as benzoin, camphor, creasote, etc. (Formulæ 1 to 4). *Dry inhalations*,

such as the fumes of chloride of ammonium when that salt is exposed to great heat, or their inhalation through the mouth and exhalation through the nose, in a nascent state, by means of an apparatus such as Godfrey's inhaler (Fig. 45), are of service in removing congestive swelling of the nasal and pharyngeal mucous membrane. On the sponge in Godfrey's inhaler other volatile medicaments may be used with advantage. The fumes of ammonia, camphor, carbolic acid, menthol, iodine, or eucalyptus are employed, and usually form the constituents of popular anti-catarrhal remedies, such as Hagar's anti-catarrhal mixture (Formula 6), which is held in great estimation by some as an abortive treatment for cold in the head. The fumes of such medicines may be sniffed from a wide-mouthed bottle, from drops poured upon the inner surface of a cone of blotting-paper, from the palms of the hands, or from an inhaler such as Maw's menthol inhaler. For the various forms of dry inhalation which may be employed, see Formulæ, Nos. 6 to 10. In the form of spray (Fig. 95) *solutions* are decidedly beneficial. A 10 per cent. solution of hydrochlorate of cocaine applied in this way to the interior of the nose always relieves the sense of obstruction, and may even help to cut short the attack. A good effect is also produced by a single application of a solution of hydrochlorate of morphia (Formula 11) in the form of spray. The solution of chloride of ammonium or bicarbonate of soda also forms a useful spray. Liquid vaseline or paroleine with, in some cases, the addition of 5 per cent. of menthol sprayed into the nasal passages by means of the paroleine atomiser (Fig. 102), allays obstruction and soothes irritation. *Ointments* containing medicaments, when applied to the interior of the nose by means of a camel's hair brush or special syringe, have a useful and pleasant effect. One of the best consists of 2 grains each of menthol and cocaine with 1 drachm of vaseline. This introduced occasionally has a marked influence in relieving obstruction in the nose. Atropine ointment (Formula 28) tends to diminish excessive watery secretion from the nose, while eucalyptus ointment (Formula 29) may relieve an unpleasant sense of dryness. Certain *powders* insufflated into the

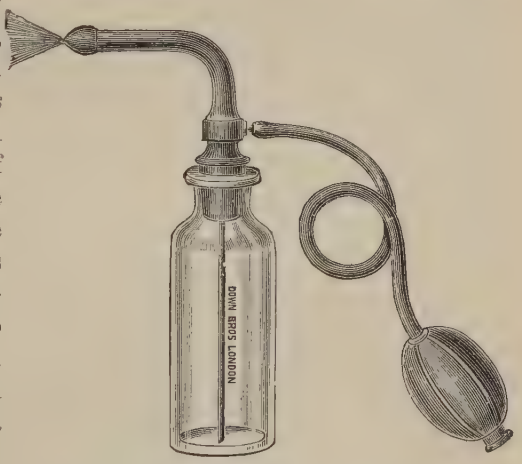

Fig. 95.—Spray producer for anterior nares.

nose may be of service. Ferrier's snuff, consisting of morphia, bismuth, and starch (Formula 37), is frequently used with the object of cutting short a cold in the head. Menthol and boracic acid, 1 of the former in 10 of the latter, is preferred by some to the other ways of using menthol. Where severe pain over the frontal sinus is a marked feature of the attack, the application of two or three *leeches* is attended by distinct relief.

General Treatment. If the attack be a sharp one, especially if there be feverishness, general treatment is required. If, at an early stage, the patient be confined to a warm, well ventilated room, and his skin acted upon by diaphoretics, such as Dover's powder, or the vapour or hot air bath with the usual domestic hot gruel, followed by a saline aperient in the morning, a cold in the head may be sometimes cut short. Other means may be used with advantage to shorten an attack, such as a full dose of opium or of carbonate of ammonia. A tumblerful of hot toddy at bed-time is a popular remedy. Spirits of camphor on sugar, and drop doses of tincture of aconite, have their warm advocates. Dr. Greville MacDonald recommends full doses of quinine and salicin, while Dr. Hovell speaks highly of the ammoniated tincture of quinine with spirit of chloroform, in doses of a drachm of the former and twenty drops of the latter, every three or four hours, the first dose to be double that quantity.

II. TREATMENT OF CHRONIC RHINITIS OR CHRONIC COLD IN THE HEAD.

In local treatment three objects must be held in view: (1) to remove the secretion and disinfect the parts, (2) to check the hypersecretion and remove the chronic swelling or hypertrophy, and (3) to remove morbid growths such as polypi or adenoid vegetations.

In the furtherance of these objects various forms of remedies are applied. These may be divided into (*a*) simple medicated applications (solutions, vapours, powders, and ointments), (*b*) cauterization of the nose, and (*c*) operative treatment.

(A) *MEDICATED APPLICATIONS.*

We shall first consider the various modes of applying *solutions*, and then the most useful kinds.

Simple Sniffing or Pouring. In sniffing, a small quantity is put into the hollow of the hand or into a table-spoon or saucer, and with moderate inspirations drawn through the nasal passages into the pharynx while the head is thrown back, and then expelled by the mouth. From a tablespoonful to a teacupful may be used in this way at one sitting. Some persons are very successful in this

mode of applying fluids to the nasal passages, while in others it produces headache or excites a fresh cold. The *pouring of liquid into the nose* is a better and safer method. Politzer pours the fluid out of a glass vessel, such as an ordinary medicine measure, into one of the nostrils while the head is inclined backwards. When the fluid passes into the upper pharynx the head is bent quickly forwards, so as to allow the solution to flow out of the opposite nasal passage. By this method the solution is brought into contact with the walls

FIG. 96.—Woakes' glass vessel for irrigating the nose.

of the naso-pharynx, including the mouths of the Eustachian tubes. Woakes employs a glass vessel for the same purpose (Fig. 96).

FIG. 97.—Siphon nasal douche.

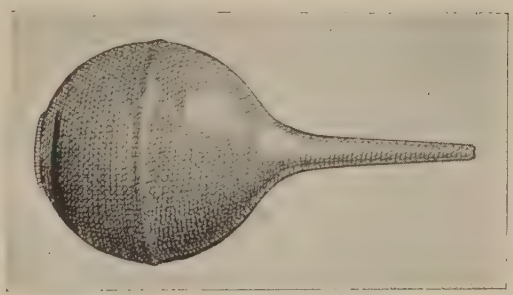

FIG. 98.—Nasal ball syringe.

Weber's Douche. The principle of the nasal douche is that, when liquid which is forced or flows into the nasal passage reaches the soft palate, the latter rises and accurately closes the communication with the lower pharynx, so that the liquid flows round and

passes out of the opposite nostril, carrying with it mucus or other secretion. The apparatus (Fig. 97) used consists of a jug or vessel capable of containing at least a pint of fluid, and an india-rubber tube furnished with a nose-piece. The other end of the tube is fixed to a perforated peg at the bottom of the vessel, or is simply placed at the bottom of the fluid in the vessel. In the former case, a catch is affixed near to the nasal end of the tube to regulate the flow of fluid; in the latter case the tube, before being used, must be exhausted of air. The vessel should be placed two or three feet above the level of the patient's head. On account of the hydrostatic pressure exerted on all sides of the nasal passages and pharynx, the fluid may force its way into the Eustachian tubes, or into the frontal sinus, exciting severe frontal headache. There is no doubt that in some instances acute inflammation of the middle ear has been caused in this way. Roosa and Knapp, of America, record such cases, while the author has observed several instances of purulent inflammation of the middle ear resulting from the use of the nasal douche (see Precautionary Suggestions, p. 131).

The Nasal Syringe. In syringing the nose, the fluid, when it reaches the naso-pharynx, flows round and escapes through the opposite nasal passage, as in the case of Weber's nasal douche. An india-rubber ball syringe with soft nozzle suits very well (Fig. 98).

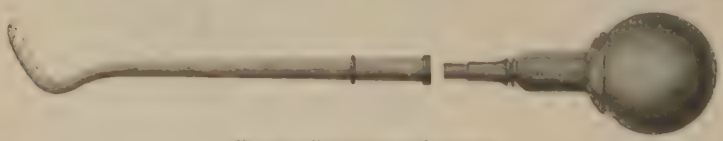

Fig. 99.—Posterior nasal syringe.

It should be large (4 oz.) if used in ozæna, but smaller (2 oz.) if used in the hypertrophic form of rhinitis. In ozæna, where a considerable volume of fluid is required, a small Higginson's enema syringe suits well. A nozzle having several apertures, such as that employed by Dr. Lennox Browne, has some advantages. A glass ear syringe (see p. 67) with india-rubber tubing over the ear-piece does very well. The stream of fluid should be directed *straight backwards* in order to avoid the frontal sinus, and the nasal piece must not be inserted too tightly into the nostril. The crusts of inspissated secretion frequently found in the nasal passages, especially in ozæna, are more thoroughly removed by the syringe than by Weber's nasal douche.

Although syringing through the anterior nares is usually sufficient to act upon the walls of the naso-pharynx, it is sometimes desirable to inject fluid directly into that cavity, and we may either use for this purpose the posterior nasal syringe, which is furnished with a long tube

(Fig. 99) terminating in a perforated extremity and curved in such a way that we are able, after passing it through the mouth, to turn the point upwards behind and above the soft palate; or we may wash out the naso-pharynx very thoroughly by injecting fluid through a silver tube of the length and diameter of a medium-sized Eustachian catheter, but closed at the inner end and without the curve, the sides of the inner end having a number of perforations. The tube being introduced through the inferior meatus of the nose, previously cocainized, until the perforated part is in the upper pharyngeal cavity, the liquid is forced into its outer opening by means of a syringe or the syphon tube of the nasal douche, and in this way a number of small jets issuing from the small perforations are directed against the walls of the naso-pharynx.

Spraying and Painting. A very convenient and useful mode of applying solutions to the interior of the nasal passages and pharyngeal cavity is that by atomized or spray inhalations. A Richardson's spray apparatus, with an acorn-shaped point, suitable for introduction into the nostrils, is required (Fig. 95). A fairly powerful spray is necessary to ensure that all the interstices of the nasal passages and the naso-pharynx shall be acted upon. A special form is made for the introduction of oleaginous substances (Fig. 101). Apparatus are also constructed for spraying the naso-pharynx from the throat (Fig. 100). During the use of the spray, the patient should breathe through the mouth and keep the eyes closed.

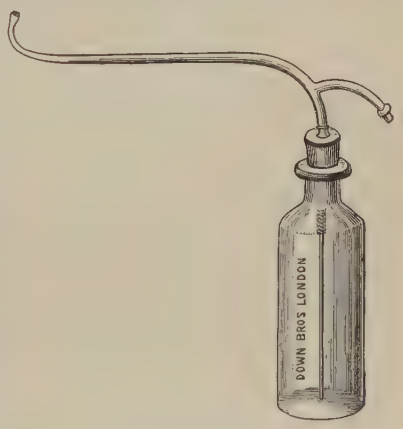

FIG. 100.—Spray producer for posterior nares.

Certain solutions should be applied by *touching* or *painting*. For the anterior nares a camel's hair brush or the cotton-holder with cotton wool, as in the case of the ear (see p. 5), is very suitable. For the naso-pharynx, a small ball of cotton wool held with curved forceps, or a curved cotton-holder, is introduced behind the soft palate and applied to the walls of the naso-pharynx. A solution may be applied to the mouth of the Eustachian tube by means of a small piece of sponge fixed to the end of a wire, introduced through a wide Eustachian catheter while the latter is *in situ*.

Cleansing and Antiseptic Solutions. Many kinds of solutions are applied to the naso-pharyngeal mucous membrane in these various ways. Alkalo-saline solutions are probably the most frequently employed, and have the effect not only of cleansing the mucous

membrane but also of reducing catarrhal swelling. The following give a sufficient variety: (1) Equal parts of bicarbonate of sodium and chloride of sodium; (2) equal parts of bicarbonate of sodium, chloride of sodium, and borax; (3) equal parts of chlorate of potassium and bicarbonate of potassium; (4) equal parts of chloride of sodium, bicarbonate of sodium, and chloride of ammonium. In all of these a drachm of the powder to a pint of tepid water is a fair strength, but for different persons this may require to be modified. These and other medicaments are prepared in the form of tabloids by Burroughs, Wellcome & Co., for convenience of patients when travelling. The solution should not be applied in a strength which proves irritating.

More powerful antiseptics for conditions such as are found in ozæna may be used with advantage—*e. g.* (1) potassium permanganate, 30 minims of the B. P. solution to a pint of water; (2) boracic acid, 2 drachms to a pint of water; (3) chlorate of potassium, 1 drachm to a pint of water; (4) aceto-tartarate of aluminium. (M'Bride speaks favourably of this in ozæna—1 drachm of a 50 per cent. solution is mixed with a pint of tepid water.) All these may be used by any of the methods just described with exception of the last, namely, that by *painting*. In ozæna cleansing solutions may require to be continued for months or even years.

Stronger Medicated Applications. In addition to cleansing and disinfecting applications, we generally require to act upon the mucous membrane by various astringent, absorbent, or caustic substances. These are employed in smaller quantities, not usually more than an ounce at a time, and if there is much secretion in the nasal passages their use may be preceded by a bulkier cleansing or antiseptic solution. A selection from the following may be made, and it is sometimes desirable to alternate one with another.

(1) Any of the preceding alkalo-saline solutions with 2 grains of carbolic acid to the ounce. (2) 4 grains of tannin to an ounce of water. (3) Equal parts of salicylate of sodium, bicarbonate of sodium, and chlorate of potassium, of which 3 grains to the ounce may be used. These three solutions may be applied by means of the small syringe, the spray, or the pouring-in method just described. (4) Paroleine and fluid vaseline, bland and tasteless products of petroleum, have been much used, and apparently with advantage, by means of an atomizer (Figs. 101 and 102), in both acute and chronic rhinitis. They have a soothing effect, and soften crusts, while they are good media for many other medicaments, such as menthol, eucalyptus, iodoform, thymol, salol, and ichthyol (Formulæ 12 to 15). (5) Rectified spirit —1 to 4 of water—in the form of a spray has been recommended by Baber for the roots of polypi after operation, and for hypertrophic catarrh: this has been employed by the author with much benefit.

(6) Iodine may be employed with advantage in hypertrophic conditions of the naso-pharynx in a solution with glycerine, iodide of potassium, and carbolic acid (Formula 45). (7) A 10 per cent.

FIG. 101.—Paroleine atomizer.

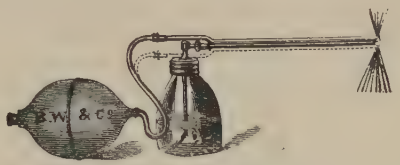

FIG. 102.—Paroleine atomizer for naso-pharynx.

solution of hydrochlorate of cocaine is often applied, by means of the spray or cotton swab, in small quantity before examination, or as an anæsthetic before the use of the cautery, and other operations.

Precautionary Suggestions. The following precautions should be kept in view when applying solutions to the nasal passages and naso-pharynx, in order to avoid or diminish the risk of exciting inflammation in the middle ear. (1) Patients before using the nasal syringe, Weber's douche, or the hand douche, should be carefully instructed by the surgeon in their proper and safe use. (2) Previous to injecting fluids by the syringe or Weber's douche into the nose, or prescribing such, the nasal passages should be carefully examined, and if one should be found obstructed, the fluid should be injected *into the obstructed passage.* (3) The nozzle of the syringe should not *tightly* close the nostril, and during the injection of the fluid the stream should be interrupted. (4) If a syringe is employed, too great force must not be used, especially if there be resistance to the flow of the fluid from one nostril to the other; if Weber's douche is employed the fall must not be too great—not more than two feet. (5) The fluid injected should always be comfortably warmed—say 80° to 90° F.—and it should hold in solution a saline, such as a 1 per cent. solution of common salt or bicarbonate of sodium, while in ozæna or other bacterial diseases a definite antiseptic should be employed. (6) The act of swallowing, being attended by the opening of the Eustachian tube, must carefully be avoided during the douche; this is aided by breathing through the mouth. Eitelberg suggests that the patient should protrude the tongue so as effectually to prevent the act of swallowing. (7) In the case of infants or very young children, or in adults whose Eustachian tubes are abnormally permeable, the syringe or Weber's douche should not be employed. The liquid should in these cases be poured into the nasal passages with a spoon or other suitable appliance, while the patient (if old enough) should sound the syllable "*ah.*" (8) The patient should not blow his nose or, if possible, sneeze, for at least fifteen minutes afterwards; he should be instructed that in the event of the liquid entering the ear, he must swallow several times with the nostrils closed.

Vapours—Powders—Ointments. *Vapours* are most useful in acute rhinitis, or in an acute exacerbation of the chronic form (see p. 124).

Powders are frequently applied to the nasal passages and naso-pharynx for the reduction of thickened mucous membrane and

hypersecretion. In some cases cleansing is essential before the insufflation of any powder. By simple sniffing the powder may be brought in contact with the anterior parts of the nasal passages. But some form of insufflator is usually required, and that described for the ear (Fig. 103) is very suitable. In order to insufflate powder from the throat into the naso-pharynx we must use a bent vulcanite tube whose wall has an opening which, after the powder has been introduced, is closed with a slide, while the insufflation is performed. Powders may also be applied to the upper pharynx through a wide Eustachian catheter whose beak is weakly curved. When the catheter is introduced through the nasal passage, its point is directed to that part of the naso-pharynx requiring the powder, which is then blown out of the tube. When the powder is intended for the mouth of the Eustachian tube, the catheter is introduced through the opposite nasal passage, and its beak moved so as to hook round the posterior edge of the nasal septum. The powder is then blown upon the mouth of the opposite Eustachian tube. A straight tube is most suitable when the powder is intended for the posterior wall of the pharynx. A variety of substances are used in the form of powder. Finely powdered tannin is useful, *but alum is unsuitable in consequence of its occasionally injuring the sense of smell.* Menthol along with boracic acid (Formula 38) has a pleasant effect in relieving a sense of stuffing, and it acts as an antiseptic. The addition of 5 per cent. of cocaine (Formula 39) adds still further to the effect. Ferrier's snuff is useful in acute exacerbations. On the whole, however, powders are less frequently suitable than solutions, although they may sometimes be alternated with advantage.

Fig. 103. Ball insufflator.

Ointments are often serviceable applications. In eczematous conditions of the nostrils, especially in children, the frequent use of an ointment containing zinc or a mild mercurial is beneficial for softening the crusts and exercising a healing effect. Vaseline and iodoform (Formula 26) are also useful in healing slight abrasions or ulcerations in the interior of the nasal passages. The use of menthol, cocaine, and vaseline often gives much relief (Formula 30) when there is a sense of stuffiness in the nose. Atropine ointment and eucalyptus ointment are also sometimes used with advantage (see p. 125).

(B) *CAUTERIZATION OF THE NOSE.*

Nitrate of Silver. For removing chronic swelling of the mucous membrane, a solution of nitrate of silver (40 grains to the ounce) is

sometimes of service, applied by the surgeon himself. After cleansing the nasal passages, the nostril is dilated in the usual way, and by means of cotton wool on a cotton-holder similar to the one used for the ear, the solution is applied to all the accessible mucous membrane, till the parts are whitened. Afterwards the patient should plug the nostril for a minute or two with cotton soaked in a weak solution of salt. We may in this way apply the caustic solution to the greater part of the mucous lining of the nasal passages. When we wish to apply it to the naso-pharynx, the cotton-holder should be longer and curved. A good plan of applying the solution to the Eustachian tube is by means of a small piece of sponge fixed to the end of a wire introduced through a wide Eustachian catheter while the latter is *in situ*. There is usually no more irritation produced by the application of a solution of nitrate of silver than a temporary feeling of heat or burning, which, if severe, can be relieved by an injection of a weak solution of common salt. When applied to the mouths of the Eustachian tubes there may be increased deafness and tinnitus for a short time from temporary increase of the swelling. Sometimes after a few applications the mucous membrane is rendered much more healthy; at other times this treatment requires to be repeated every third day for two or three weeks.

Chromic Acid. Applied to limited parts of the mucous membrane, which may be the seat of circumscribed hypertrophy or intense general swelling, chromic acid is advantageously employed. For example, hypertrophied mucous membrane over the inferior or middle spongy bone and the roots of polypi are often much reduced by repeated applications of chromic acid. M^c^Bride considers that chromic acid is particularly suitable in cases attended with much secretion, owing to the diffusive action of the acid. Moistened with a very small quantity of water it should be applied on the point of a silver probe or platinum holder made for the purpose (Fig. 104), or it

Fig. 104.—Woakes' chromic acid carrier.

may be fused on one of these points heated to a dull red over a spirit lamp. To afford more space for its application, the parts should first be cocainized. If it be inadvertently applied to a part not intended, or if it excite much pain, syringing or moistening the parts with a solution of bicarbonate of sodium will neutralize its caustic effects. It must not be applied over too large a surface at one time in case of producing excessive irritation or even

toxic effects. In many persons great sneezing and irritation of the nose and eyes follow the use of chromic acid. For a few days after the application care should be taken to avoid syringing the nose or exposure to cold. A case is known to the author in which severe purulent disease of the middle ear, including the mastoid cells, was excited by the patient travelling from London the night after such a cauterization.

The Galvanic Cautery. This is the most efficient means of destroying hypertrophied tissue in the nasal region. A platinum burner, different patterns of which are shown in Fig. 105, attached to a suitable handle (Fig. 106), rendered red-hot by the galvanic current, and applied several times, at intervals of ten days or a fortnight, to the hypertrophied tissue, is, in careful hands, effectual, safe, and attended by very little pain if preceded by the application of a 10 per cent. solution of cocaine. It is most commonly applied to the inferior turbinated body; the burner should be introduced if possible to a point near its posterior end and then with moderate pressure it is moved forward so as to plough the mucous membrane. In a marked case two or three furrows may be made at one sitting. Usually the slough does not come away in less than a week, when it may have to be removed in considerable masses with forceps. The ointment of cocaine, menthol and vaseline (Formula 30) should be used twice or thrice daily till the slough separates, but it is desirable to avoid for several days syringing the nose and exposure to cold or septic influences. In a persistently swollen state of the erectile tissue of the turbinated body, without actual hypertrophy, the thrusting of a red-hot pointed burner (Fig. 107) into three or four places is sometimes more useful in leading to contraction of the tissue than the surface burning. When the hypertrophy consists of well-marked outgrowths either along the inferior turbinated body or at its posterior extremity, a galvano-caustic loop (Sheeh's apparatus, Fig. 108) can be made to encircle the mass and remove it without the same amount of bleeding as with the cold snare or the "spoke-shave" of T. Carmalt Jones.

Fig. 105.—Galvano-caustic burners.

Fig. 106. Handle of galvano-cautery.

Fig. 107. Pointed burner.

(C) *OPERATIVE TREATMENT.*

Nasal Polypi should be removed with a Wilde's snare of greater length and strength than the one used for aural polypi. There

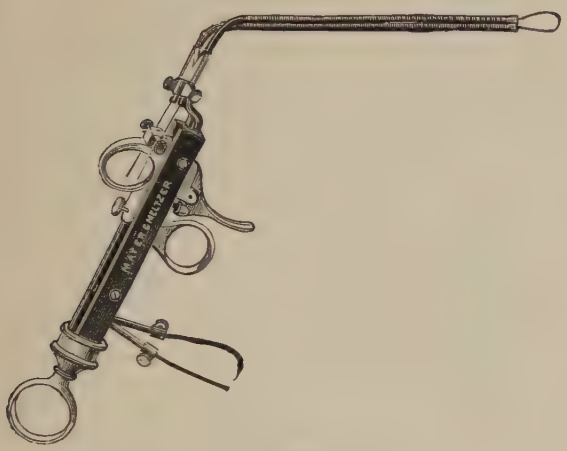

Fig. 108.—Shech's galvanic écraseur.

Fig. 109.—Blake's nasal snare.

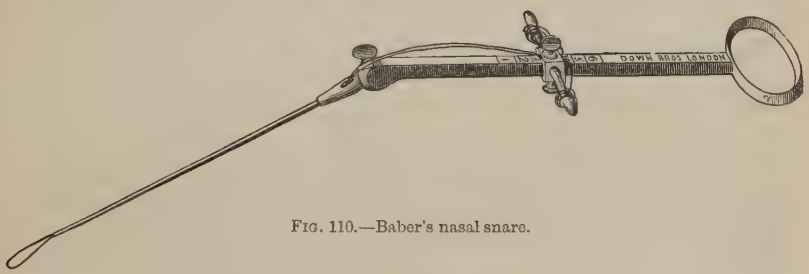

Fig. 110.—Baber's nasal snare.

Fig. 111.—Jarvis' nasal écraseur with end for naso-pharynx.

should be an arrangement on the stem of the instrument for fixing the ends of the wire by means of a screw clamp. Many snares are now constructed with a fine tube containing the wire, such as Blake's (Fig. 109) or Baber's (Fig. 110). The interior of the tube should be carefully cleaned after use. Jarvis' nasal *écraseur* (Fig. 111) or some of its modifications, such as Fig. 112, is useful for its screw action, especially in removing hypertrophic tissue. When a polypus projects into the naso-pharynx through the posterior nares,

the stem should be bent in order to introduce it behind and above the soft palate. Through a speculum introduced into the nasal passage, and well illuminated by means of a forehead mirror, a strong loop made of No. 5 piano wire is introduced and made to encircle the growth, and then pushed up as near the root as possible; the cross-bar or ring is then pressed home, and by traction the growth is plucked from its attachment to the mucous membrane. Rarely can the nose be cleared at one sitting, as, after the removal of a few growths, the bleeding obscures the parts. Cocaine should of course be applied previous to operating. In cases where the polypus hangs into the naso-pharynx, it may be necessary to introduce the finger into the naso-pharynx to place the loop over the growth. As compared with forceps, this method is attended by much less pain, less bleeding, and less danger of injuring the mucous membrane or spongy bones. If a great tendency exists to recurrence of the polypi, the galvanic cautery or chromic acid should be repeatedly applied to the roots, or to the hypertrophied mucous membrane forming the bases of the polypi. The employment of spirit spray (see p. 130) for some weeks after the removal of polypi tends to shrivel up any roots which may remain.

FIG. 112.—MacDonald's snare.

The Removal of Spurs or Ridges on the septum, or the rectification of deflected portions, is an operation regarding the propriety of which very diverse opinions are held by authorities. Their operative removal would no doubt be called for (1) if they produce marked nasal obstruction and seriously embarrass breathing through the nose, (2) if they seem to be responsible for the persistence of rhinitis, or (3) if they are associated with severe paroxysmal sneezing, which is unaffected by all other forms of treatment. Although in persons suffering from middle ear deafness there may be found spurs or ridges on the septum, if there is an absence of nasal symptoms we are not justified in operating. The majority of persons with perfect hearing have such spurs or deflections.

The mode of operating is usually with fine saws (Fig. 113), or

with a trephine (Fig. 114) in the form of a circular saw or knife propelled by a dental engine or an electro-motor. A plug of gauze

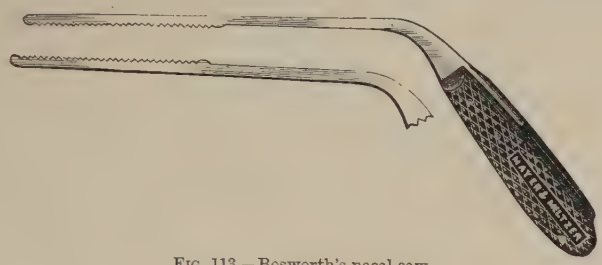

FIG. 113.—Bosworth's nasal saw.

saturated with an oleaginous antiseptic (Formula 12) should be kept in the nasal passage operated upon till the healing process is complete; the plug should be changed daily.

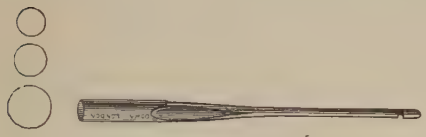

FIG. 114.—Nasal trephine.

The forcible distension of the nose with an instrument resembling a glove stretcher has been strongly recommended by Dr. Hewetson of Leeds.

T. Carmalt Jones has devised an instrument, termed the "spoke-shave" (Fig. 115), for removing the turbinated bones (*turbinotomy*). It is also recommended for removing ridges on the septum or posterior hypertrophy of the inferior turbinated body. The instrument is introduced so that the posterior end of the turbinated body is felt to be in the open space of the instrument, when a quick, steady pull severs it. Jones alleges that the operation relieves deafness and subjective sounds in a considerable proportion of cases. He has operated on "quite five hundred turbinals"—see his paper, with discussion, in the *Brit. Med. Journal*, 23rd Nov., 1895.

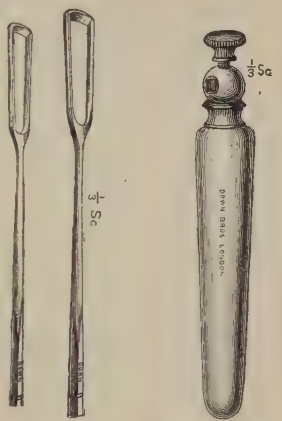

FIG. 115.—Carmalt Jones' spoke-shave.

III. TREATMENT OF POST-NASAL ADENOID GROWTHS.

Importance of Early Removal. As stated, these vegetations tend to atrophy and disappear spontaneously when adult age is reached, and hence the question may be asked: Why not wait for their spontaneous disappearance? No doubt in slight cases presenting

few symptoms, and especially if unattended by ear mischief, no harm would follow this policy of waiting. In most instances, however, such delay is fraught with evil consequences. Semon gives the following reasons against delay in removing these growths: (1) the influence of the obstruction upon general health, mental development, and the formation of the face, results which may remain even if the glands themselves undergo atrophy; (2) the danger of ear complications; and (3) the greater liability to, and seriousness of, infectious diseases, especially diphtheria and scarlet fever.

The Question of Anæsthetics. There is no doubt that a general anæsthetic adds a slight element of risk to this operation, which, without an anæsthetic, may be said to be absolutely free from danger. On the other hand we find that in children or very nervous adults it is very difficult without an anæsthetic to eradicate the whole of the growths, at any rate at one sitting. A general anæsthetic is more frequently given in this country than on the Continent, where it is quite customary to repeat the operation, it may be several times. One of the chief risks in operating under an anæsthetic is that of blood finding its way into the larynx or bronchial tubes, causing asphyxia or subsequent inflammation of the lungs. This danger may be said to be almost entirely averted by the adoption of a suitable position for the patient, by the prompt use of sponges, and above all by a proper method of giving the anæsthetic. Most surgeons operate with the patient's head hanging backwards over the end of the operating table, so that the blood or fragments of detached growth may pass out through the anterior nares or mouth. Unfortunately this dependent position of the head tends for the time being to increase the bleeding, which, however, as a rule soon ceases after the head has been raised. Some operators, such as Mr. Hovell, prefer that the head should be on a level with the body, and trust to the rapid mopping up of the blood with sponges. Mr. Butlin operates with the patient on his side, the thighs being flexed and the head bent a little forward on a low pillow. Mr. Braine, in giving nitrous oxide gas and ether, chiefly for the operation with the finger nail, first places the patient in the semi-recumbent position, and when the narcosis is sufficiently complete, he flexes the trunk forcibly on the thighs and operates—the blood after the operation escaping from the mouth and nose into a basin placed between the patient's knees. In the curette operation under an anæsthetic the author always operates with the dependent position of the patient's head, and even then rapid removal of the blood by sponges is necessary to prevent the suction of blood into the trachea. With nitrous oxide gas the sitting posture may be justifiable.

Selection of the Anæsthetic. In regard to the kind of anæsthetic employed, the fact of several deaths having occurred from the use of chloroform has led some to discard it, and to resort to ether or nitrous oxide gas, or to both. It is alleged in favour of ether that the power of coughing and swallowing is generally retained, and that the noisy respiration of ether anæsthesia, compared with the quiet breathing of chloroform, keeps one better informed as to the state of the respiration; while, in the event of obstruction to the respiration, the heart's action under ether does not fail so quickly. On the other hand, the large quantity of frothy secretion which is usually poured into the throat,

and the more profuse bleeding due to great venous turgidity, are highly objectionable features of ether narcosis, while the laboured and stertorous breathing, instead of being an advantage, may rather tend to suck the blood and frothy secretion into the larynx. Nitrous oxide gas may suffice with the nail operation, or even with a rapid curette operation, but it does not allow of sufficient time for the use of forceps. In order to save time, the gag should be introduced before the beginning of the administration of the gas. Some operators begin with nitrous oxide gas, then go on to ether, and, when the patient is fairly deeply anæsthetized, they continue with chloroform till the end of the operation. While the author has operated both with ether and nitrous oxide gas as anæsthetics, his experience has led him to prefer chloroform, cautiously and sparingly given on a mask, with a plentiful supply of air, care being taken that, while the corneal reflex is abolished, the cough and swallowing reflexes should not be entirely in abeyance. It is important, however, that, though very deep chloroform narcosis is to be avoided, it should be deep enough to relax the muscles of the throat and to prevent retching during the operation. When the growths are numerous and large, prolonging the operation, the anæsthesia may be cautiously maintained by pumping in more of the vapour through a tube from Junker's apparatus held at the side of the gag. It is right to mention, however, that such an important authority on anæsthetics as Dr. Silk disapproves of giving chloroform or any other anæsthetic after anæsthesia has been induced and the operation begun. Upon the importance of this Dr. Silk places great stress. Here it may be remarked that a competent anæsthetist, with special experience in these cases, is of importance. He should wait beside the patient till perfectly satisfied that the latter is safely out of the anæsthetic. The deaths which have occurred seem to have been in some cases due to the neglect of this precaution. While the surgeon and anæsthetist turned aside for a few minutes to attend to some other matter, thinking the operation was safely completed and the anæsthesia passing off satisfactorily, the patient died from sudden failure of the heart's action.

Modes of Operating. Of the many methods of operating for the removal of these growths that with Gottstein's curette, or some of

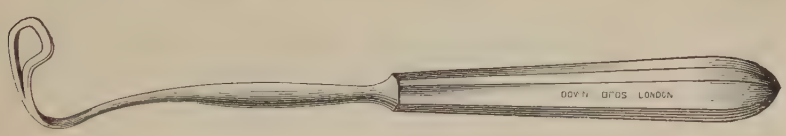

FIG. 116.—Gottstein's curette.

its modifications, is probably the simplest and most efficient, and it will be first described. Sometimes a combination of methods is adopted—the forceps for removing the large tough portions, and the curette and finger-nail for the softer variety and for those growing on the lateral walls of the pharynx.

Gottstein's Curette and its Modifications. Gottstein's curette (Fig. 116) is a triangular fenestrated instrument attached at a right angle to a long handle. The inner edge of the base of the triangle is sharp as a knife. In this country, when Gottstein's curette is

employed, the patient is usually anæsthetized with chloroform, and lies on his back with the head hanging well over the end of a table and supported by the hands of an assistant, the back of the neck resting on a firm pillow. A waterproof cap, similar to a bathing cap, should cover the head, in order to prevent the blood which flows from the nose getting into the hair. A large towel or piece of jaconet should envelop the upper part of the body. A gag (Mason's) should be applied on the left side, well guarded with thick india-rubber tubing, so as not to injure the teeth or gums. The teeth should be examined, and if a loose tooth is found care must be taken in case the gag should separate it altogether and endanger the patient by the tooth slipping into the larynx during the operation; any false teeth are to be removed. The chloroformist is at the head of the patient, the operator at the right side, and an assistant for attending to the gag and sponges at the left side. A dozen small honeycomb sponges, clean and aseptic, secured on sponge holders, should be at hand. The finger is introduced into the naso-pharynx to determine the quantity, situation, and character of the growths. The triangular end of the curette is then introduced behind and above the soft palate, with its convexity upwards and backwards, avoiding the lateral walls, until the blunt edge of its base is in contact with the posterior edge of the nasal septum. The handle is now grasped firmly, the curette is pressed well upon the roof of the pharynx, and drawn backwards and then downwards, so that the sharp edge is made to sever all the vegetations in its sweep. With the ordinary curette, the vegetations, removed in this way, are either expelled through the nose, mingled with the blood, or are mopped up with

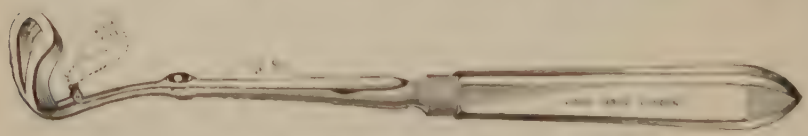

Fig. 117.—Modification of Gottstein's curette.

the sponges, or are swallowed. A useful modification (Fig. 117) has recently been introduced, in which there is an arrangement with two sharp prongs in front of the triangular steel frame, for detaining the vegetations cut off with the sharp edge of the curette. The writer usually employs three strokes before withdrawing the curette, and then, with one sponge quickly introduced after another into the pharynx, the blood is mopped up by the assistant. Once more the cavity is examined with the finger, and if any growths are still found the curette is again introduced, or the finger nail may be sufficient. If the curette is employed without an anæsthetic, the

patient should be seated on a chair having a low, broad-cushioned back, over which the head is bent and supported by an assistant. After cocaine has been freely applied to the walls of the naso-pharynx, the tongue is pressed down with a spatula, and the curette is employed in the same manner as when an anæsthetic is used.

After-Treatment. It is well, after an anæsthetic operation, that the patient be turned on his side, retaining the head on a level with the body, or somewhat raised, while the gag is kept between the teeth for a minute. Some operators, in order to prevent bleeding, maintain pressure on the walls of the naso-pharynx for a few minutes with a sponge or folded lint in curved forceps. In most cases, however, blood is swallowed in considerable quantity, frequently exciting vomiting, the vomited matter consisting of blood mixed with the contents of the stomach. It is well always to warn the friends that vomiting is likely to take place, if it has not already done so, and that some one should be at hand beside the patient ready to help. Pieces of ice placed in the mouth after the patient has regained consciousness, tend to check the sickness. The ice may be given at intervals for twenty-four hours, during which the patient should abstain from *hot* liquids or solids. Bleeding of an alarming nature is very rare, and pressure upon the roof of the naso-pharynx by means of a roll of cotton moistened with a styptic solution introduced with forceps will easily control it. The patient should rest in bed for two days, and keep the house for a week after the operation, during which no local treatment of the nose with douche or syringe should be employed. These precautions are especially important in damp, cold weather, so as to avoid middle ear inflammation. Injudicious nasal douching after the operation may excite inflammatory mischief in the middle ear.

Enlarged Tonsils. Not infrequently adenoid post-nasal growths are found associated with hypertrophied tonsils. Probably the safest plan is to remove first the enlarged tonsils, if possible without an anæsthetic, and then, after the healing process is complete, the post-nasal growths should be operated upon. Some specialists remove the tonsils and the post-nasal growths at the same time under an anæsthetic, and in certain cases this is perhaps the best method. To produce so extensive a bleeding surface, however, might in some persons be attended by considerable risk, partly from the bleeding and partly from the greater risk of septic infection.

Mouth Breathing after Operation. If mouth breathing continue in spite of the operation, and we are confident that the post-nasal growths have been thoroughly eradicated, we should carefully examine the nasal passages in order to make sure that no obstruction exists there. If, on either side, the inferior spongy body is found to be

enlarged or hypertrophied, cauterization with the galvanic cautery or chromic acid may be required. In mild forms of obstruction a prolonged and careful use of an alkalo-saline solution with a spray apparatus or a suitable syringe may prove sufficient. If the obstruction be due to spurs upon the septum or to deflections, these may require operation, but such forms of obstruction are not common in childhood. If, after the mechanical impediment to free nasal breathing has been removed, the mouth breathing still continue, means must be adopted to help the person to overcome this habit. The simple plan should be first tried of causing the patient to sit still for fifteen minutes, twice or thrice daily, during which he studiously keeps the mouth closed and breathes through the nose alone. If after a time this proves insufficient, an appliance should be provided consisting of a small india-rubber cup, on which the chin rests, the cup being kept in position by means of bands secured round the head. This should be worn for a time at night, so as to keep the lower jaw from falling. Or we may use an india-rubber band with a mouthpiece of soft leather, secured round the head during sleep, so that the leather mouthpiece covers the mouth and compels nasal breathing. Another plan, which the author has known a female patient to adopt, is to retain the lips in contact during sleep by means of long strips of sticking plaster. Some writers ridicule the use of these aids to nose breathing, alleging that, if the nose and naso-pharynx are really free from obstruction, the breathing will naturally become nasal without any such contrivances, and that, if there is defective nasal breathing, we shall find a mechanical cause in the nasal cavities, which must be removed by suitable treatment. Undoubtedly, however, mouth breathing has been remedied by these artificial helps, where it had persisted after ample breathing space had been secured in the nose and naso-pharynx.

Löwenberg's Forceps and their Modifications. Many operators prefer the use of forceps devised by Löwenberg (Fig. 118), and modified at different times by various workers. When patients or their friends shrink from the use of a general anæsthetic, this mode of operation is probably more convenient and less painful than other methods. With the patient seated on a chair, and the head, arms, and legs firmly held, light is reflected in the ordinary way into the pharynx. With the blades closed, the forceps are introduced as far as the posterior wall of the pharynx. The blades are then pushed up to the roof of the naso-pharynx, when they are widely separated and made to lay hold of one or more of the adenoid projections, which are brought away partly by cutting and partly by traction. The forceps may in this way be introduced three or four times at one sitting. The blades of the forceps should have their cutting edges above and behind, while there should be a free space in front, so as to lessen the chance of catching hold of the septum of the nose. Owing to the anxiety of the operator to avoid the septum, the growths immediately behind it are apt

to escape the forceps. Mr. Hovell (who discards all curettes or scraping instruments) has modified the forceps so that the two cutting edges are circular, and do not meet edge to edge, but are so arranged that the one blade encloses the other, their action being thus that of a punch (Fig. 119). He claims for this modification that it avoids the risk of pulling away shreds of mucous membrane, or of injuring the septum. Whatever forceps may be used it is important that they should not be too large. Many of those sold by instrument makers are much too large for children, in whom most of the cases of post-nasal growths occur. Just as in the case of the curette operation, the finger nail may be used with advantage to remove any fragments which may remain after the forceps have been employed. If the operation is performed during anæsthesia, the patient should lie on his back with his head on a level with the body. A gag is used as in the curette operation, and the index finger of the left hand is introduced into the naso-pharynx, with the back of the hand downwards and forwards, so as to guide the blade of the forceps to the individual growths. In this way the forceps are introduced several times and the growths individually pulled or cut away until, as informed by the finger, they are all removed. This sounds very satisfactory, but in practice it is often found to be no easy

FIG. 118.—Löwenberg's Forceps.

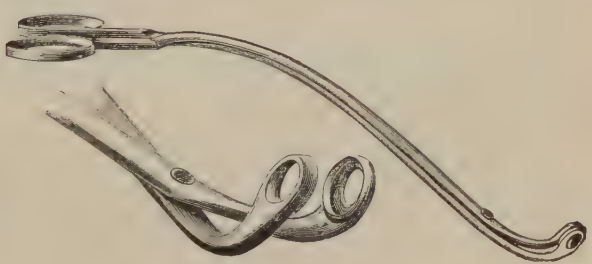

FIG. 119.—Hovell's forceps.

matter to accommodate the index finger and the blades of the forceps in the small naso-pharynx of a child so as to manipulate freely, and the efforts to do so often lead to much bruising and injury of the parts. When operating with the forceps, while the head hangs over the end of the table, great care should be taken to avoid laying hold of the nasal septum. Forceps have been recently introduced having an antero-posterior movement, thus avoiding the catching of the septum.

The Finger-Nail Operation. Some authorities, such as Pritchard, Field, and Lennox Browne, seem to trust entirely to this method, which was first advocated by Dr. Guye, of Amsterdam. There is a decided feeling, however, on the part of most specialists that this method of removal is in general insufficient, and that, when employed, subsequent operations are not infrequently required. Only in the softer and flatter forms, occurring in very young children, is this method of scraping them away with the finger nail sufficient by itself to eradicate the growths. The finger nail may, however, be

employed with advantage for the clearing away of remnants of growths after the use of a curette or forceps. If the finger-nail treatment be employed, the nail of the right index finger should be properly pared, so as to be neither too short nor too long. If too long, the nail is apt to bend or even break when tearing off the vegetations. The finger nail should, of course, be scrupulously clean, and, before operating, it is a good plan, as proposed by Mr. Pritchard, to immerse it for a short time in rectified spirits, both for its antiseptic effect and its hardening influence on the nail. If no general anæsthetic be given, a 10 per cent. solution of cocaine should be applied to the naso-pharynx, either as a spray through the nasal passages or with a plug of cotton on forceps introduced from the lower pharynx. The cocaine is more efficient in adults, as we are able in them to apply it more freely, and with greater safety, to the walls of the naso-pharynx than in children. The child is seated on a chair while the arms and legs are held firmly by assistants, and the right index finger is introduced into the mouth, moved rapidly backwards, and turned up behind the soft palate. The nail is then made to tear or cut through the soft tissue on the roof and back wall, and from the neighbourhood of the Eustachian prominences, if any exist there. In order to prevent the patient biting the finger of the operator, the first phalanx and the metacarpo-phalangeal joint should be protected by thick india-rubber tubing, or, as some operators do, by pressing the cheek of the patient between his teeth on the left side. In some cases the soft palate moves backwards before the finger, so as to close the way to the naso-pharynx and prevent the introduction of the finger. In such cases it is a good plan to introduce a uvula retractor, and press the uvula and soft palate firmly but gently forward with the left hand. When the finger is well into the naso-pharynx the retractor is withdrawn.

Fig. 120. Artificial nail.

The Artificial Nail. An artificial nail of steel (Fig. 120) is used by some authorities, such as Dalby, Capart, and Bezold. It is fixed to the index finger, and being, of course, stronger than the natural nail, is more capable of penetrating and removing the growths. But its use is unsatisfactory, owing to the impaired tactile sensibility and the increased bulk of the finger. Justi and Trautmann employ an artificial nail fixed on the end of a stem which is attached to the finger.

Hartmann's Curette. Hartmann's curette (Fig. 121) is preferred by some operators, such as Krause of Berlin, and Bronner of Bradford. The force is

Fig. 121.—Hartmann's curette.

applied laterally, and not antero-posteriorly as with Gottstein's curette. An anæsthetic is rarely used by those who employ this instrument. The patient, if a child, sits upon the knee of a trained assistant, who, with the legs and left hand, fixes respectively the patient's legs and arms, and at the same time holds the patient's head firmly with the palm of the right hand placed against the patient's forehead. In this way the head of the patient is held

immovably against the chest of the assistant. Light is reflected into the throat, the tongue is depressed by a spatula, and the curette is pushed up into the naso-pharynx. It is firmly pressed upon the posterior wall and roof of the naso-pharynx, then it is moved, as on a pivot, to one of the lateral walls, and the edge of the curette is made to sweep across to the opposite side with firm pressure, so as to sever and remove the vegetations in its course. This method is apt to leave untouched the growths in the front part of the naso-pharynx, while it may injure the Eustachian prominence and excite middle ear disease.

Golding-Bird's Curette. This is an oval fenestrated instrument (Fig. 122) connected with a long stem bent at rather more than a right angle near the

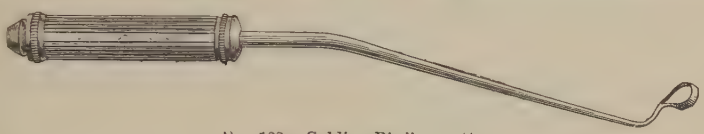

FIG. 122.—Golding-Bird's curette.

fenestra. The cutting or scraping edge, instead of being on the inner aspect of the base, is found on the lower side. It is applied in a similar way to Gottstein's curette, but, on account of the position of the scraping edge, it penetrates more deeply, and is particularly suitable for scooping out the growths situated at the junction of the roof and back wall of the naso-pharynx. This seems to be a serviceable instrument.

Meyer's Ring Knife (Fig. 123). We must not omit to mention the method of operating adopted by the late Professor Meyer, of Copenhagen, the first to draw

FIG. 123.—Meyer's ring knife.

attention to the existence of these growths in the naso-pharynx. He operated through the nasal passages, and used a ring knife having one sharp edge, attached to a steel stem, which is introduced through the wider nasal passage. When the knife has reached the naso-pharynx it is turned horizontally, if the growth be in the roof. The left index finger of the operator is introduced through the mouth into the upper pharynx, and the ring knife is pressed up so as to encircle one of the growths, when the knife is drawn forwards, severing the growth. Few operators have followed this method.

IV. TREATMENT OF THE THROAT.

The mucous membrane lining the throat frequently requires treatment in connection with ear disease.

Treatment of Acute Conditions. The acute forms of sore throat—such as acute pharyngitis or acute tonsillitis—are not such important causes of ear disease as the chronic forms. In the acute cases the sucking of small pieces of ice, or the sipping of iced and sweetened barley water flavoured with lemon, does good in many cases; while in others the inhalation of the vapour of hot water from a narrow-mouthed jug, either simple or medicated with benzoin

or oil of pine (Formula 1), suits better. Painting or spraying with menthol (Formula 12) or cocaine (Formula 13) soothes the pain of swallowing. Dissolving tabloids of chlorate of potassium slowly in the mouth, or gargling with a solution of the same (Formula 54), is often very beneficial. Guaiacum lozenges internally are said to be useful in the rheumatic form, for which also 10 to 20 grains of salicylate of sodium every few hours, or 15 grains of salol four times daily, are given. If the inflammatory process is chiefly in the interstices of the tonsils and suppuration takes place, the inhalation of steam and the application of poultices outside soothe the pain and tend to bring forward the abscess, which, when fully matured, should be opened with a knife, the edge of which is directed towards the middle line of the pharynx, and is protected with sticking plaster to within half an inch of the point.

Treatment of Chronic Conditions. Much more frequently, however, ear affections are associated with chronic affections of the throat. When the throat is simply relaxed, soft, and swollen, the use of *gargles* (Formulæ 50 to 54) or *sprays* (Formulæ 53 to 55) or *medicated lozenges* (Formulæ 56 to 61) is recommended. The usual method of *gargling* is often ineffective, as the liquid rarely comes in contact with the throat proper, but remains in front of the anterior pillars of the fauces. The method of von Tröltsch may be tried. While the head is inclined backwards, the liquid is allowed to flow into the back of the throat, when the muscular movements of swallowing are to be performed several times, without actually allowing the liquid to be swallowed. In this way not only is the liquid applied more effectively to the throat, but at the same time the pharyngo-tubal muscles are exercised, and a good influence is thereby exerted upon their functional activity in opening the Eustachian tube. The gargle should be employed at least night and morning, and in many cases three or four times a day. The ingredients of gargles are very various. Many patients are benefited by simply using a glass of fresh water morning and evening, or half a teaspoonful of common salt dissolved in half a pint of water. Chlorate of potassium, borax, tannin, and alum gargles are all employed (Formulæ 50 to 55). While the solution of alum may be beneficial to the mucous membrane, it is destructive to the dentine. The same solutions are usefully applied in the form of *spray*. When there is dryness of the throat the inhalation of the vapour of creasote (Formula 4) is useful. Suitable sedative and astringent *lozenges* are given under the Formulæ, Nos. 56 to 61. Menthol pastilles are antiseptic and anæsthetic. While lozenges are a very convenient and pleasant mode of applying medicaments to the pharyngeal mucous membrane, care must be taken not to injure the digestion by their too frequent use.

When the congestive swelling or thickening is more pronounced, stronger stimulation is essential, and the applications must then be made by means of a brush or of cotton on a cotton-holder, Glycerine of tannin, glycerine of carbolic acid, glycerine of tannin and carbolic acid, solution of perchloride of iron, and solution of iodine (Formulæ 46 to 49), are probably those from which most benefit is derived. A solution of iodine, iodide of potassium, and carbolic acid in oil of peppermint and glycerine (Formula 45) is probably one of the most useful, employed once or twice daily for several weeks. The others may be used daily, and they should, in most cases, be continued for several weeks.

Granular or Hypertrophic Pharyngitis. When there is localized thickening of the mucous membrane, the solution of iodine (Formula 45) will be found an excellent application. But in the treatment of this condition, cauterization with the galvanic cautery of the particular hypertrophied parts is undoubtedly the most efficient mode of treatment. A small flat burner (Fig. 51, *b*) should be employed to each individual reddish elevation or enlarged follicle on the posterior wall of the pharynx, or laterally if there is hypertrophy of the lateral bands. A sore throat is the result for a few days, during which the voice is rested, exposure to cold avoided, and an antiseptic gargle used. An alkalo-saline spray is useful for a few weeks afterwards. It has to be mentioned that attention to the general health is requisite in the treatment of granular pharyngitis. Gouty, rheumatic, dyspeptic and anæmic conditions, or nervous exhaustion, must be treated first.

Hypertrophied Tonsils. When these exist in connection with deafness, they should be removed or diminished in size. By acting as a foreign body in the throat they maintain the catarrhal process. They may also, by pressing up the *velum palati* and its mucous membrane, partially or completely close the mouths of the Eustachian tubes, and interfere with the function of the tube muscles. Besides, by obstructing the breathing they probably injure the respiratory organs and hinder the proper development of the thorax. While substances such as nitrate of silver and iodine have little effect upon hypertrophied tonsils, the repeated use of the galvanic cautery may be followed by considerable diminution in their bulk, and this may suffice when the hypertrophy is not very marked. The knife or the *tonsillotome* is, however, the most rapid and the most thorough mode of treatment, and the one which should be generally adopted. Behag's modification (Fig. 124) of Mackenzie's tonsillotome (Fig. 125) is probably the best instrument. A general anæsthetic is rarely necessary, but the application of a 10 per cent. solution of hydrochlorate of cocaine before operation is useful. The patient is seated

with an assistant supporting the head, light is reflected into the throat from a forehead mirror if necessary, and the tongue is depressed; the

FIG. 124.—Behag's tonsillotome.

ring of the tonsillotome is made to encircle the enlarged tonsil and is pressed well to the side so as to enclose as large a portion as possible. By the action of Behag's instrument the tonsil is pulled out of its

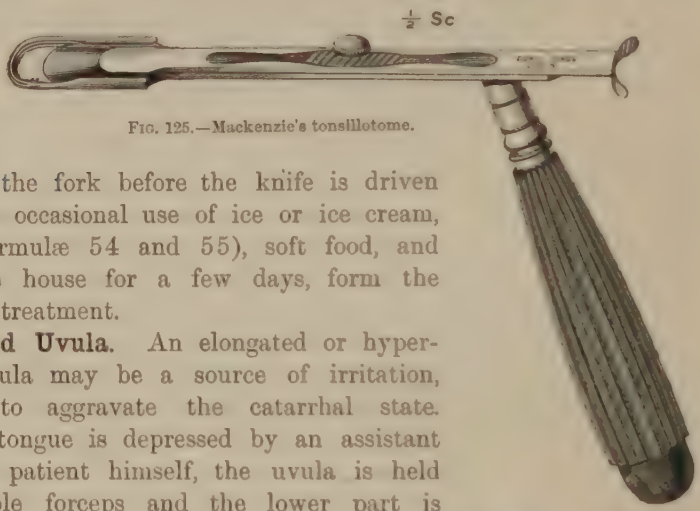

FIG. 125.—Mackenzie's tonsillotome.

niche with the fork before the knife is driven home. The occasional use of ice or ice cream, gargles (Formulæ 54 and 55), soft food, and rest in the house for a few days, form the subsequent treatment.

Elongated Uvula. An elongated or hypertrophied uvula may be a source of irritation, and tend to aggravate the catarrhal state. While the tongue is depressed by an assistant or by the patient himself, the uvula is held with suitable forceps and the lower part is snipped off with uvula scissors in such a way that the raw surface is situated behind. The treatment afterwards is similar to that following the removal of enlarged tonsils.

Constitutional Treatment of the Chronic Affections of the Nose and Throat. In chronic inflammations of the nasal and pharyngeal mucous membrane, constitutional treatment is frequently of great advantage. For the anæmic and strumous conditions, iron tonics, cod liver oil, plenty of fresh air, and a sufficiency of nutritious food form good adjuncts to local treatment. In the syphilitic, the gouty, or the rheumatic diathesis, appropriate remedies must also be prescribed (see Formulæ). The digestive functions may require attention.

CHAPTER VII.

DISEASES OF THE AURICLE AND EXTERNAL MEATUS.

I. THE AURICLE.

ANATOMICAL AND PHYSIOLOGICAL DESCRIPTION.

Structure. The *auricle* or *pinna* (Fig. 126) is that part of the ear which projects from the side of the head. It covers a considerable area of the mastoid and squamous parts of the temporal bone. The middle segment of the concha extends 15 to 20 mm. backwards on the mastoid area, a fact which should be kept in view in operating on the mastoid. The auricle is composed of a framework of yellow elastic fibro-cartilage covered with perichondrium and skin. In the lower or most dependent portion—the lobule—the cartilaginous tissue is absent, there being here fat and connective tissue in its place. The auricle becomes much more soft and flaccid in advanced years. The skin, especially in the concavities, is richly supplied with sebaceous glands and hair follicles.

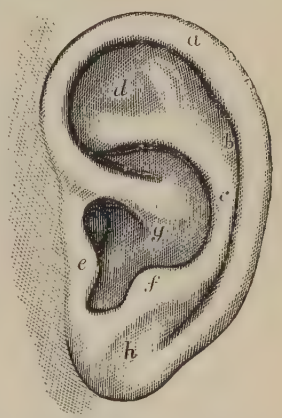

FIG. 126.—Auricle—*a*, helix ; *b*, fossa of the helix ; *c*, antihelix ; *d*, fossa of the antihelix ; *e*, tragus; *f*, antitragus ; *g*, concha ; *h*, lobule.

Various Parts of the Auricle. The outer or anterior aspect presents concavities and eminences which have received distinctive names. The posterior and upper edge folded inwards is termed the *helix*, but in many persons, instead of being folded it is partially or wholly flat ; and frequently a projection, more or less marked, is seen at the upper part, and is looked upon as a homologue of the folded ears of the lower animals (Darwin). The ridge, forked at the upper end, in front of the helix, is named the *antihelix*. Between these two is the fossa of the helix or *fossa navicularis*. The concave space enclosed by the forked upper terminations of the antihelix is termed the fossa of the antihelix or *fossa triangularis*. The lower prominent extremity of the antihelix is called the *antitragus*. The large deep concavity in front of the ridge of the antihelix is the *concha*, divided into two parts by the commencement of the ridge of the helix. The concha passes into the external canal of the ear. In front of and overlapping the external opening of the ear is the nipple-shaped projection of the *tragus*, whose inner surface is often the seat, especially in elderly men, of a tuft of bristly, stiff hair. The notch between the tragus and the antitragus is termed the *incisura intertragica*.

Varieties of Auricles. The auricle presents great varieties in length and breadth, as well as in the inequalities on its surface and in the size of its angle of attachment to the head. These varieties are connected partly with family peculiarities, partly with peculiarities of race, partly with habits of dress, and partly with the effects of disease. In women, for example, who have for years worn caps closely applied over the ears, the auricle may often be seen lying flat against the head. Intertrigo of the back of the ear in childhood may produce the same abnormally close application of the auricle to the side of the head. Again, the marked projection of the ear from the side of the head, so striking a peculiarity in some men, is occasionally due to, or at least aggravated by, the common habit of boys wearing their caps closely pulled down between the auricle and the head. The form of the lobule of the ear may be sadly marred by the constant traction exercised by heavy ornaments suspended from this part of the ear.

Muscles. The auricle is furnished with so-called extrinsic and intrinsic muscles—three of the former and six of the latter; but these are extremely rudimentary in man, and hence the auricle is usually capable of only a very limited amount of movement.

Function of the Auricle. This part of the ear does not seem to contribute materially to the power of hearing. It has been repeatedly observed that the loss of an auricle had little if any effect upon the acuteness of hearing, and we may therefore look upon it chiefly as the homologue of the more highly developed and more useful organ of the lower animals. Probably, however, the different concavities, especially the concha, by collecting the waves of sound and reflecting them into the external auditory canal, aid somewhat in the transmission of sound to the deep parts and in increasing the perception of it. The fact that deaf persons frequently improve their hearing by pressing the auricle forwards shows that it exercises some influence on the hearing. The hollow formed by the inner surface of the tragus is of use in guiding the waves of sound, which have been collected and reflected by the concha, into the external auditory canal (Politzer). By some writers the auricle is thought to act as a resonator for high tones.

INJURIES OF THE AURICLE.

The auricle from its exposed situation is liable to injuries, which may be of the nature of incised wounds or contusions.

Incised Wounds, on account of the irregularity of the surface of the auricle, should be brought together by means of sutures. If the auricle is permanently severed, an artificial one may be substituted. A gap in the lobule—cleft lobule—is not unfrequently seen as a result of the wearing of ear-rings. Either by the mere weight of a heavy ornament, or by violence, the lobule is torn through, and when the two separated edges of the wound have cicatrized a cleft remains. This deformity is easily rectified by carefully paring the edges, and accurately bringing them together by sutures.

Traumatic Hæmatoma Auris. Contusions often lead to important results, especially if, in consequence of previous disease,

the cartilaginous tissue has been weakened and has on that account been ruptured by the injury. In this way the condition named "Hæmatoma auris" or "Othæmatoma" may have a traumatic origin. The blood effused into the tissue, usually between the perichondrium and the cartilage, which in some cases is fractured, forms a sanguineous swelling at the upper and anterior part. At first this swelling (Fig. 127) has generally a dark reddish-blue appearance, but it may have the natural colour of the skin, and there is considerable pain and a feeling of tension. After a time, the

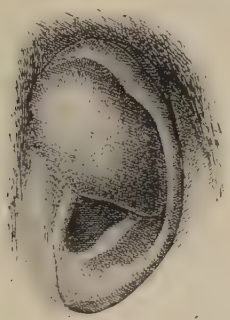

FIG. 127.—Traumatic hæmatoma auris, due to the pressure of a heavy sack of grain carried on the shoulder.

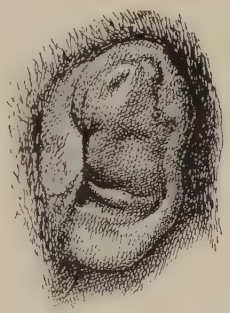

FIG. 128.—The shrunken ear after hæmatoma auris in an insane patient.

contents may consist of straw-coloured fluid owing to the deposition of the colouring matter of the blood upon the walls of the cavity. If the effused blood is imperfectly absorbed, organization of the contents of the swelling takes place with thickening of the surrounding tissues, followed ultimately by contraction. The normal ridges and concavities become in this way partially or wholly effaced, and in the course of time the auricle may be converted into a shrunken, shapeless mass—the so-called shrunken ear (Fig. 128). The most serious deformity ensues when the cartilage has been torn by the injury. This deformity is not unfrequently seen in professional boxers. The swelling may be due to perichondritis with serous effusion. It then appears as a fluctuating swelling, containing serous or sometimes purulent fluid, generally occupying the fossæ of the concha and helix.

SPONTANEOUS HÆMATOMA AURIS.

Hæmatoma auris may also arise without a traumatic cause. The swelling may be developed spontaneously and very quickly, so that in a few hours it may attain the size of a walnut. Here there is less pain and less tendency to serious deformity than in those cases which have a traumatic origin.

Frequency in the Insane. The insane seem specially liable to this sanguineous swelling, although it may also occur spontaneously in persons of sound mind. By some it is contended that even in the insane its origin is always traumatic. Its association chiefly with such forms of insanity as acute mania and general paralysis, where there is greater liability to injury, inflicted either by the patients themselves or by attendants, and its preference for the left ear, are the most important facts adduced in favour of this view. Specialists on insanity are now, however, pretty generally agreed that, while hæmatoma auris in the insane may arise from an injury, and that a slight one, its occurrence without any traumatic cause is indisputable. There seems to be therefore in the insane a special tendency to this effusion of blood in the tissue of the auricle, with the consequent shrinking, and the predisposing cause is probably some morbid change in the cartilaginous tissue and blood-vessels; the former having previously become softened or degenerated. In the ear not affected with the tumour we sometimes find nodulated, thickened portions of cartilage. The walls of the vessels have also become weaker from the softening process in the cartilage, so that slight causes, such as a gentle blow, pressure, or even the hyperæmia of mental emotion, may produce a rupture. Some writers suggest the probability of a connection existing in the insane between the circulation in the brain and that in the ear as accounting for these effusions of blood. If the "shrunken ear" come under observation, it is well to inquire into the past history of the patient, especially as to the question of insanity.

Treatment of Hæmatoma Auris. When traumatic in origin, this should consist, at the early stage, in the use of cold, moist applications or the lead lotion (Formula 66), with moderate pressure. Afterwards we should employ remedies to promote absorption or to counteract inflammatory reaction. If pain be very severe and the swelling remain undiminished after some time, the fluid should be evacuated by aspiration, which, if it re-accumulates, may have to be repeated. If this fails, free incision may be required, with removal of the contents and stuffing with iodoform gauze. When it is due to perichondritis and the contents are serous, Pritchard recommends the repeated injection of tincture of iodine after aspiration, and this was employed with success by the author in the case figured No. 127.

CUTANEOUS AFFECTIONS.

Eczema of the Auricle. This is the most frequent affection of the auricle which comes before the surgeon. As in other parts of the body, it may occur in the *acute* or in the *chronic* form.

Acute eczema manifests itself by great redness and swelling, with a sense of heat and tension. As a result of the swelling the organ appears to project abnormally from the head. The disease may at this stage be mistaken for erysipelas. After a short time a more or less extensive crop of vesicles appears, from which there soon begins to exude a reddish yellow fluid, sometimes containing blood; or the exudation may take place without the formation of vesicles. This fluid, by drying, forms crusts or scabs, which cover the cutis now denuded of its epidermis. The disease may be attended by more or less febrile disturbance.

Chronic eczema is met with much more frequently than the acute. It is often a part of, or an extension from, an eczematous condition affecting the face and scalp. Poulticing, the application of irritating substances, or the contact of discharge from the ear is often responsible for it. It may involve the whole of the auricle, but more frequently it is limited to individual parts. It is, for example, not uncommonly met with in the lobule, originating perhaps from "boring the ear," or more frequently from the irritation of discharge from the ear. Behind and above the auricle, at its attachment to the head, is also a common situation for the disease to appear, either as a red moistened surface or as a fissure having a red and moist basis denuded of epidermis. It also frequently attacks, and tends to linger in, the fossa of the helix. In the most chronic form there is often very considerable infiltration of the skin, which is yellowish brown, reddened, and covered either with inspissated secretion or with numerous epidermic scales. There are also frequently fissures, out of which fluid exudes, and which are apt to bleed. Great itchiness is now the predominant feeling. Acute exacerbations, however, may take place, when besides the itchiness there is a painful sense of heat and tension. When this condition of chronic eczema is allowed to go on without treatment, or is of the nature of eczema impetiginosum, the auricle may be transformed into a thick brownish-red shapeless mass covered with offensive crusts and scabs or marked with fissures. There is frequently also considerable loss of hearing from the induration and thickening of the skin at the outer opening of the external auditory canal.

Treatment of Eczema of the Auricle. In the *acute* form this consists in protecting the ear against pressure, and at the same time excluding the atmosphere by dusting the part with a fine powder, such as finely powdered starch (Formula 40). A solution of subacetate of lead is also very useful, alleviating the sense of heat and probably shortening the acute stage (Formula 66). A drachm of liquor plumbi subacetatis in an ounce of fresh milk is said to form

a soothing application. The diachylon ointment is also a very useful application after the first few days (Formula 18). A purgative (see Formulæ) may be prescribed, and only light diet should be permitted.

The treatment of *chronic* eczema should be continued for a long time, and the topical applications may require to be varied repeatedly. We should be careful to treat the neighbouring parts of the head if they are also affected, and we must prevent hairs getting into the moist cracks, and so irritating them. Applications of an astringent and stimulating nature are most suitable. We must be careful, however, in the event of an acute exacerbation, attended by great heat and pain, to abstain from stimulating remedies, and must resort to the soothing means recommended for acute eczema. The auricle should be protected by a light and soft covering made for the purpose, so as to avoid the contact of dirt or exposure to injurious pressure. When there is a great tendency to the formation of crusts, the milder stimulating and astringent applications are to be used, such as the diachylon ointment (Formula 18), benzoated oxide of zinc (Formula 19), boracic acid in vaseline (Formula 25), or subnitrate or oleate of bismuth with benzoated lard and vaseline (Formula 31). The ointment should not only be applied over the diseased surface, but also smeared thickly over narrow strips of soft linen and laid into the various depressions of the auricle. The ointment should be wiped, not washed, off. It is useful also occasionally to bathe the parts with the solution of subacetate of lead. If the scabs are very difficult to remove, they should be frequently saturated with almond oil or vaseline, and then light warm poultices of bread crumbs applied. If there be great induration, infiltration, or epidermic formation, applications of a more distinctly stimulating character must be used; and for this purpose tarry and mercurial preparations are most useful. Formulæ Nos. 16 and 17 are mild stimulating ointments, with which we may begin. When there are great scaliness and dryness with itchiness, either of the Formulæ Nos. 17, 20, or 24 may be employed. The use of super-fatted tarry soap would be suitable for this condition. It is to be remembered that the presence of moisture and heat in the skin necessitates caution in the use of stimulating substances. In scaly eczema of a very chronic character, mainly affecting the entrance to the external auditory canal, painting with a strong solution of nitrate of silver (Formula 86) two or three times, at intervals of three or four days, is very beneficial.

Internal remedies are frequently necessary in the treatment of chronic eczema, especially of the scaly variety. Arsenic and iron are the most important of these, and their use should be continued for a considerable time (see Formulæ). If we have to deal with a scrofulous patient, cod liver oil should be given in addition to the iron or

arsenic. The fresh open air of the country and nutritious food are here, as in all chronic diseases, very helpful in bringing about a cure.

Herpes Zoster occasionally affects the auricle. In its distribution the eruption corresponds either with the auriculo-temporal branch of the trigeminus or with the great auricular branch of the first cervical nerve. Some persons are periodically affected with herpes zoster on the auricle. It is usually attended with severe neuralgic pains.

Erysipelas frequently extends from the face to the auricle, although it rarely affects this part primarily; it has been known, however, to originate in the external meatus during the existence of a purulent affection of the middle ear. The swollen œdematous and reddened appearance may possibly be mistaken for the early stage of acute eczema, especially as vesication may appear in erysipelas. The nature of the case is clear when we find, as is usually the case, that it simply forms a part of erysipelas of the face and head.

Lupus occasionally attacks the auricle either in the form of lupus vulgaris or lupus erythematodes, the former sometimes producing serious deformity and partial adhesion of the auricle to the side of the head. In the symptoms and treatment there is no essential difference between this disease when it affects the auricle and when it attacks other parts of the body. The student is therefore referred to works on dermatology for further information.

Frost-bite. Under the influence of intense cold, especially in persons having a feeble circulation, the auricle may be frost-bitten, and in this way even completely destroyed by gangrene. In milder cases a local dermatitis is produced, the part affected simply appearing red and inflamed; in more severe forms there may be small livid nodules which become pale on pressure with the finger, and may lead to excoriations. Vesicles or ulcerations are occasionally seen. The treatment of frost-bite consists at first in the local application of iced water or in gentle friction so as to restore the circulation. Afterwards the lead and opium lotion and frequent bathing with hot water do good. The nodules should be painted either with tincture of iodine, collodion, or equal parts of the liniments of camphor and belladonna. If there is excoriation, an ointment, such as boracic acid or iodoform, with vaseline, should be applied. The results of the inflammation must be treated on ordinary surgical principles.

Diffused or Furuncular Inflammation of the skin of the auricle, or abscess, may occur either as part of a like process in the external auditory canal or as the result of improper poulticing of the ear. The lead lotion should be employed for the diffuse form; and for the furuncular variety the applications to be described for the same disease, when occurring in the external auditory canal, will suffice.

Comedones, Seborrhœa, Erythema, and other skin affections are sometimes found on the auricle, but their situation here invests them with no special claim for further consideration.

MORBID GROWTHS.

Various kinds of morbid growths, simple and malignant, are occasionally met with on the auricle. *Epithelioma* is a very rare affection. *Fibrous growths* and *hypertrophy* of the lobule, when they do occur, have probably in most cases their origin in the irritation produced by the insertion or wearing of ear-rings.

Vascular tumours, as *angioma* and *nævus*, are rarely met with. The author has seen a case in which the dilated pulsating vessels were also on the neighbouring parts of the mastoid and head. *Sebaceous cysts* have occasionally their seat on this part of the body. These morbid growths are to be dealt with, when they occur on the auricle, in the same way as on other accessible parts of the body.

CONGENITAL MALFORMATIONS OF THE AURICLE.

The auricle may suffer congenitally from *excess* or *defect* of formation or from *abnormal position*. Complete supernumerary

Fig. 129.—Auricular appendages (from photograph by Hartmann).

auricles—polyotia—have been only very rarely met with. Not unfrequently, however, one or two cartilaginous or cutaneous protuberances are seen in front of the tragus, and these appendages are looked upon as very rudimentary additional auricles—the auricular appendages of Virchow (Fig. 129).

Defective Formation of the Auricle. Defective formation or development has more important consequences. Complete absence of the auricle is very rare, for there usually exists some rudiment of the organ, however imperfect in size or formation. Sometimes it is represented by a cartilaginous ridge, at others by a small cartilaginous or cutaneous projection. In the marked forms the arrested development of the

auricle is generally associated with a defective condition of the external auditory meatus, which may consist of a fine canal terminating in a blind extremity. The tympanic ring is usually absent, while the whole middle ear, including in some cases the canal for the facial nerve, frequently shares in the malformation. Cases are, however, known where an extremely rudimentary condition of the auricle existed with quite a normal state of the other parts of the organ. Anomalies of formation of the auricle seem to be often attended by some abnormal state of the palate and maxillary bones. The author has recently seen a child whose auricles are represented by small cartilaginous ridges with no auditory meatus, in whom there is also marked cleft palate (Fig. 130). He has also seen an infant having a nævus on the forehead, associated with defective auricle and absence of the external meatus (Fig. 131). If the sentient part of the ear is not seriously involved, a certain amount of hearing is compatible with defective formation of the auricle and of the external auditory canal. The writer has had an opportunity of making an examination of a child in whom there were only the most rudimentary auricles, with complete absence of the external auditory canals, and he was convinced, both from his own observation and the statements of the mother, that an appreciable amount of hearing was possessed by the child. The late Dr. Allen Thomson described the cases of several persons with congenital closure of the external auditory canals, who were capable of hearing speech in a moderately loud voice. The possession of partial hearing in such cases is probably due to the fact that the labyrinth, which has an entirely distinct mode of development, is frequently quite normal in formation. The middle and external ears are remnants of the first branchial cleft, from the posterior margin

FIG. 130.—Malformations of auricles in infant who had also cleft palate.

FIG. 131.—Malformation of auricle in infant in whom there is also a nævus on forehead.

of which the auricle is developed. The labyrinth, on the other hand, arises from an invagination of the primordial integument. An indentation or short canal ending in a *cul de sac* is sometimes met with in front of the tragus or on the helix, the so-called *fistula auris congenita*, a partial persistence of the first branchial cleft, frequently containing milky-looking material.

Treatment. As a rule operative interference, having for its object the artificial formation of a passage for the waves of sound, is not attended by any benefit. In cutting down into the small *cul de sac* representing the external auditory canal we usually come upon bone showing an osseous closure farther in. An exploratory incision, however, might be tried and could do no harm.

II. THE EXTERNAL AUDITORY MEATUS.

ANATOMICAL AND PHYSIOLOGICAL DESCRIPTION.

The *external auditory canal* (Fig. 132) is a somewhat winding tube consisting partly of bone and partly of cartilage, about an inch long, extending from the auricle to the tympanic membrane which separates the canal from the cavity of the tympanum.

Walls of the External Meatus. The *osseous* section of the canal forms the inner two-thirds. The roof consists of two plates, the upper forming part of the floor of the middle cranial fossa; the lower plate terminates internally at the margo tympanicus. The floor presents a convexity in the central part, and extends further inwards than the roof, the latter reaching further outwards. The posterior wall extends further outwards than the others, and forms the anterior wall of, and is in close relation to, the antrum mastoideum and mastoid cells. The anterior bony wall forms the posterior wall of the glenoid fossa. The *cartilaginous* section is continuous with the cartilage of the auricle; but at the upper and back part the tube is formed by membrane. The cartilaginous part contains several transverse clefts, *incisuræ Santorini*, which are filled up with fibrous membrane, while it is fixed to the bone by means of fibrous tissue, thus allowing movement of the walls of the canal when the auricle is stretched. The movements of the lower jaw are communicated to the cartilaginous meatus.

Curvature of the Canal. The curvature in the course of the canal is caused mainly by a rounded angle, usually well marked, at the junction of the cartilage and bone in the antero-inferior wall. From this projection the cartilaginous part slopes in an outward direction pretty abruptly downwards and forwards, while the osseous portion slopes more gradually downwards, inwards, and slightly forwards to the tympanic membrane. Near the membrane the sinking of the floor is sometimes very considerable, this depression being called the *sinus* of the external auditory canal. In consequence of this depression it is often difficult to see the antero-inferior part of the tympanic membrane, while here also small foreign bodies may escape detection, and larger bodies may become very firmly fixed, so as to render their removal difficult. The

upper and back walls of the canal are comparatively straight. Two practical considerations follow from the curved direction of the canal. (1) In introducing the aural speculum, or when syringing the ear, the auricle should be drawn upwards and backwards, so that the angle at the antero-inferior part of the canal may be partially removed. (2) In syringing the ear, the point of the instrument should be placed on the upper wall, for if it be placed on the lower or anterior wall, the stream will probably rebound from the angular projection, and the deep parts may remain untouched. The width and course of the canal present many varieties. In some persons it is wide and straight, while in others it is narrow and curved.

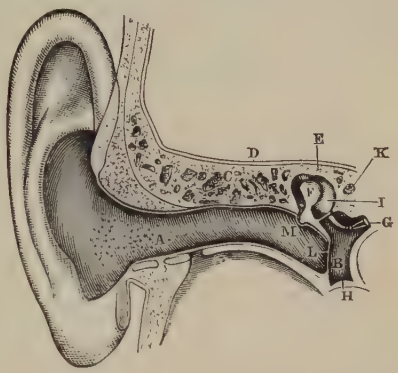

FIG. 132.—Vertical section of the external auditory canal, tympanic membrane, and tympanic cavity (right ear). A, Ceruminous glands in the external auditory canal; B, tympanic cavity; C, cellular spaces in the roof of the canal; D, dura mater lining upper surface of roof of canal; E, roof of tympanic cavity; F, head of the malleus; G, foot-piece of stapes; H, floor of tympanic cavity; I, body of incus; K, Fallopian canal; L, tympanic membrane; M, short process of malleus.

Lumen and Length. The lumen of the canal is usually oval in shape. The long diameter has a vertical direction at the entrance, while further in it becomes horizontal, and nearer to the membrane it has an oblique direction. The narrowest part, *the isthmus*, is about the middle of the osseous portion. When foreign bodies are forced beyond this the difficulty in their extraction is much increased. Although the *axis* of the canal is about an inch in length, the anterior and inferior walls are longer than the posterior and superior. This inequality in length is due to the oblique position of the membrane, which will be afterwards described.

Meatus in Infancy. At birth the walls of the external auditory canal consist only of membranous tissue attached to the annulus tympanicus. After birth the osseous canal gradually develops, and the membranous part gives place in course of time to bone. Behind and above, the osseous canal is formed by the gradual development outwards of the mastoid and squamous sections of the temporal bone; while in front and below, termed the tympanic plate, it is formed by new deposition of bone at the annulus tympanicus (Fig. 133), which, at birth, is a separate bone to which the tympanic membrane is attached. A gap in the ossification of this wall is found during the first few years of life and occasionally in the adult. In infancy there is very little bulging of the antero-inferior wall of the canal, while at that time of life the lower and

FIG. 133.—The annulus tympanicus at birth, greatly enlarged. (Rüdinger.)

front walls are twice as long as the upper and back walls. This is due to the more horizontal position of the membrane in early childhood, when it is almost parallel with the floor of the canal, from which it is separated by an extremely narrow space. This space is filled at birth with epidermic debris, the so-called *vernix caseosa*. It has been suggested that the infant for a few weeks after birth does not hear (von Tröltsch).

Lining of the Canal. The external auditory canal is lined by a continuation of the general cutaneous covering of the body. The skin lining the cartilaginous portion of the canal and a part of the roof of the osseous canal is fairly thick, and contains all the elements of skin. At the inner part of the cartilaginous canal are found the *glandulæ ceruminosæ*, seen as small dark points, which secrete the cerumen or ear-wax, and which are similar in structure to the sudoriparous glands. The cerumen, which in the normal condition consists chiefly of fatty and colouring matter, forms a circular yellowish white layer, having the consistence of honey, at the inner end of the cartilaginous part of the canal. Over the osseous portion of the canal, except at the roof where a triangular prolongation of thicker skin extends to the membrane, the skin is very much thinner and is destitute of glandular elements, but still has fine hairs. It is very firmly adherent to the periosteum, which really constitutes its deep layer and is almost inseparable from it. Inflammation of the cutaneous covering of the osseous part of the external auditory canal is therefore more of the nature of a periostitis, and is usually attended by much pain. Hence also inflammatory affections of this part are attended by risk of caries, necrosis, or hyperostosis in the subjacent bone. It is also to be observed that the lining of the external auditory canal, not being of the nature of a mucous membrane, cannot secrete mucus, and it is not correct to speak of catarrh of this canal. If flakes of mucus are found here, they must have come from the mucous lining of the middle ear, either through a perforation in the membrane or through a fistulous opening in the osseous wall communicating with the mastoid cells.

Relations to Neighbouring Parts. The external auditory canal has important relations to neighbouring parts (Fig. 134). (1) The parotid gland is situated in front of and below the cartilaginous part of the canal. In abscess of the parotid gland the pus sometimes makes its way through the *incisura Santorini* into the canal of the ear. Tumours or enlargements also of the gland may close or contract the canal by pressure on the anterior and inferior walls. (2) The anterior wall of the osseous part of the canal—the tympanic plate—forms the posterior wall of the articular fossa of the jaw. In injuries to the head, due to a fall from a height, this tympanic plate may be fractured from force applied to the chin. Bleeding from the ear would, in such a case, ensue; but, when due to this cause, would not have the grave meaning usually attached to bleeding from the ear after head injuries. (3) In the young child, the tympanic plate being defective, inflammation of the external auditory meatus is apt to pass into the articulation of the jaw and the parotid gland. (4) The posterior, and to a less extent the superior wall of the osseous meatus, have a close relation to the antrum mastoideum and mastoid cells (Fig. 135). These are separated from the external canal usually by only a thin plate of bone. Collections of matter in the mastoid cells make their way not unfrequently through this layer of bone by ulceration, and either burrow underneath the cutaneous lining or burst through it into the meatus. A fistulous passage may be formed in this way, and over such an opening exuberant granulations or even polypi may spring up. (5) The upper

surface of the roof of the osseous canal forms a part of the floor of the middle fossa of the skull and is covered by dura mater, on which rests the brain.

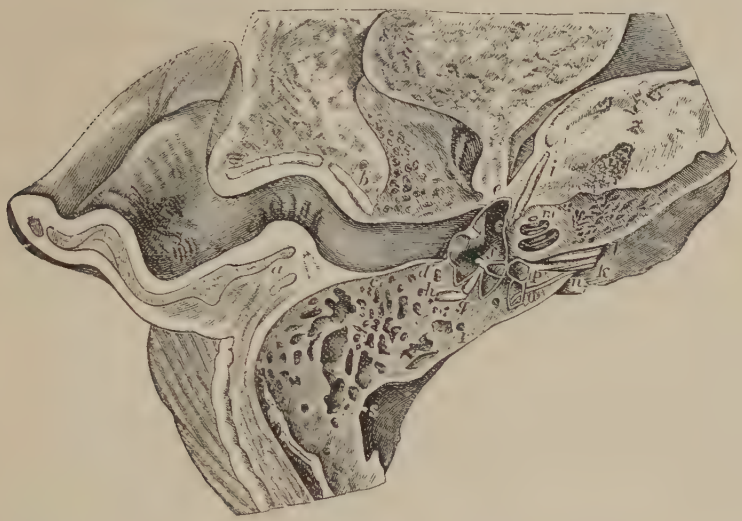

FIG. 134.—Horizontal section through the left organ of hearing, showing the curvature of external canal as seen from above, and its relations to neighbouring parts (Rüdinger): *a*, posterior wall of the cartilaginous part of the external canal; *b*, anterior cartilaginous wall corresponding with situation of parotid gland; *c*, the posterior wall of the osseous part of the canal with the mastoid cells behind; *d*, near to the insertion of the tympanic membrane; *t*, anterior osseous wall or tympanic plate; *s*, sigmoid sinus. For completed description see Anatomical Description of the Internal Ear.

There are records of cases of disease of the external auditory canal proving fatal by extension to these vital parts through the roof. The posterior osseous wall has a relation to the sigmoid sinus, which is important in operations on the mastoid. While the anterior knee of this sinus is frequently at a distance of not less than 20 mm. from this wall of the meatus, it may be much nearer, and has been found by the author as near as 5 mm.

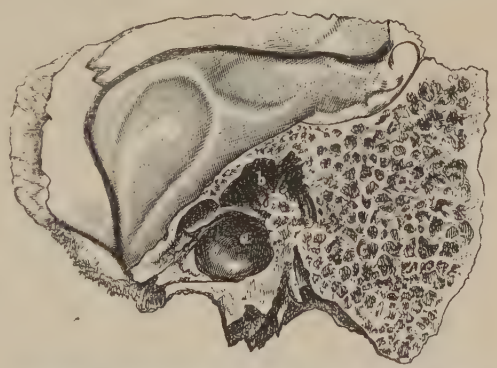

FIG. 135.—Vertical section of right external auditory canal and mastoid process seen from within: *a*, lumen of canal; *b*, antrum mastoideum; *c*, mastoid cells.

Function. The waves of sound, collected and reflected by the auricle or entering directly into the canal of the ear, are conducted by the column of air to the tympanic membrane. The reflection of the waves of sound from the curved walls of the meatus probably weakens, in some degree, their strength before they reach the membrane. It is found that there may be great contraction of the lumen of the canal without interfering with the hearing power.

EXCESS OF CERUMEN—CERUMINOUS OBSTRUCTION.

Composition of Ceruminous Masses. The accumulated masses in the ear vary in composition, consistence, and colour. They consist not only of cerumen, but also of sebaceous matter, epidermic scales, and hair, as well as foreign substances deposited from the atmosphere, such as coal dust, etc. Not unfrequently a small ball of cotton or some other foreign body occupies the centre of the mass. Their colour and consistence depend very much on the relative proportion of the several constituents. If they are composed to a great extent of laminated masses of epidermis with an admixture of cerumen and other matters, they have a yellowish or yellowish brown colour. When, on the other hand, they consist mainly of the products of the ceruminous glands with some sebaceous matter, the colour is a darker brown, which may sometimes become deep black when there is an admixture of coal dust or other black substance from the atmosphere. The presence of plates of cholesterine imparts at times a shining appearance to the surface of the plug. The consistence of the masses presents great varieties; they may be semi-fluid or soft and doughy, or of an almost stony consistence from the complete evaporation of the watery constituents. When the plugs are very old, they often appear as gray, dry masses.

These accumulations may fill the whole external auditory canal from the tympanic membrane to the outer orifice of the ear, or they may be limited to particular parts of the canal. Occasionally there may be only a thin partition at some point in the course of the canal, sufficient, however, to impede the transmission of waves of sound.

Causes of Ceruminous Obstruction. Excess of cerumen may be due (1) to an over-active state of the ceruminous glands, or to the secretion being abnormally dry and tenacious, or (2) to some defect in the natural means of escape of the cerumen from the canal of the ear. All of these factors may co-exist.

Increased secretion of cerumen is often found in persons who perspire readily, and who have a plentiful sebaceous secretion, the glands of the cutaneous lining of the ear participating in the peculiarities of the glands of the whole integument.

Irritation and congestion of the skin of the canal, temporary or permanent, are the chief local conditions which seem to excite the glands to abnormal activity. The diffuse or furuncular inflammations and eczematous conditions of the canal of the ear are apt to be followed by excessive formation of cerumen. Mechanical irritation, such as is produced by the frequent use of the point of a pen or

toothpick, with the object of relieving a sense of itchiness, or of removing particles of cerumen, has a similar effect. Diseases of the middle ear, and even of the labyrinth, are frequently found associated with excessive formation and inspissation of cerumen; hence, in most cases, the removal of the accumulation is not followed by complete restoration of the hearing power. Roosa is of opinion that "inspissated cerumen is a symptom of an inflammatory affection of the lining membrane of the canal, or of the middle ear, which has extended to the canal." It seems that catarrhal processes in the middle ear have an influence upon the secretion of the ceruminous glands; but why in some cases this influence should produce increase and inspissation of the cerumen, while in others it should act in the direction of diminishing or abolishing the secretion, is not yet clearly understood.

Hindrance to the natural escape of the cerumen from the ear may be the cause of the accumulation, although there may be no actual increase in the secretion of the glands. Thus its natural exit may be impeded by a congenitally narrow canal, or, in old persons, by a collapsed condition of the cartilaginous walls reducing the lumen to a mere slit, or by the presence of abundant bristly hairs at the entrance to the ear. Exostosis, hyperostosis, and eczematous or inflammatory thickening in the walls of the canal, also offer hindrances to the escape of the cerumen, while in these conditions small quantities of cerumen suffice to occlude it.

The efforts employed to remove the cerumen from the ear by those who entertain a fastidious desire to clean the interior of their external auditory canals, are often responsible for bringing about the very condition which they are employed to avoid. In some, these efforts are limited to the use of a towel every morning after washing, and are sometimes excited by the sense of a drop or two of water getting into the ear. A corner of the towel is screwed into a cylindrical form and pressed into the ear, pushing before it the cerumen, which is forced into the deep part of the canal. Others use a more elegant instrument, the "aurilave," consisting of a piece of sponge fixed to the end of a small handle. These efforts to clean the ear are unnecessary as well as futile. They generally result in the formation of hard balls of cerumen in the osseous meatus, or even in the packing of the secretion upon the tympanic membrane. Ordinary washing of the visible parts of the ear with the fingers will suffice to cause a cleanly appearance in adults whose ears are healthy. If, as is sometimes necessary in young children, the outer part of the canal of the ear requires special cleansing, this should be carefully done by the mother or nurse, while the part is clearly exposed to view, with the corner of a soft towel or sponge which

must be so small as to get behind the material to be wiped away.

Symptoms of Ceruminous Obstruction. These masses may go on accumulating during a long period of time, and may have formed in considerable quantities without causing any inconvenience to the patient, or even without his knowledge of their presence, provided that a gap, however slight, exists in the mass, or that no pressure is exercised upon the membrane. On the other hand, as soon as the lumen of the canal is completely occluded, although only by a thin partition, or when even a comparatively small quantity of cerumen has come to press on the tympanic membrane, deafness, frequently accompanied by other unpleasant symptoms, will be manifested.

Defective hearing may come on quite suddenly, and the patient on that account frequently considers that some disease has just affected his ear. The collection of cerumen has increased, unknown to the patient, till only a slight cleft remains, when, owing to the entrance of moisture during washing or in the bath, some swelling of the mass takes place, and the patient is suddenly and to his dismay, affected with deafness. The degree of deafness depends upon the quantity and position of the accumulation, as well as upon the presence or absence of other disease in the ear. It may be such as only slightly to interfere with the hearing of conversation, or it may be so great that if both ears are affected loud conversation cannot be heard.

For a time the degree of deafness may fluctuate considerably owing to changes in the size and position of the plug. Movements of the jaw, sudden shaking of the head, and the introduction of the finger or some instrument to allay the sense of itchiness may disturb the position of the plug. While at other times the entrance of moisture, or the drying again of previously moist cerumen, may change the size of the obstructing mass, and so account for sudden fluctuations in the hearing. Ultimately, however, when the impaction and the hardening process have been completed, the deafness becomes uniformly severe.

Subjective sounds of various kinds and degrees may also be experienced by the patient. The most disagreeable buzzing, singing, or rushing noises are complained of, and are sometimes much more annoying than the dulness of hearing. These sounds are also apt to fluctuate in intensity from the same causes as modify the degree of deafness. They are due either (1) to pressure upon the membrane, and thence through the chain of ossicles upon the labyrinthine fluid; or (2) to reflex action upon the auditory nerve from the irritation caused by pressure upon those branches of the trigeminus

and pneumogastric nerves which impart sensation to the skin of the external auditory canal.

Giddiness, even of a severe kind, may also result from the pressure of the ceruminous masses. This symptom is produced in the same way as subjective sounds, that is, either by pressure on the labyrinthine fluid, or reflexly through pressure on the nerves of the canal.

Mental disturbance with marked hallucinations of hearing have been observed, apparently based upon subjective sounds in the ear caused by the pressure of impacted cerumen, the mental disturbance being permanently cured by the removal of the impacted mass.

Pain is complained of in only a small number of cases. Occasionally, however, intense pain is felt, radiating from the inside of the ear along the side of the head. Probably, in these cases, the pressure of the hard mass has set up inflammation of the lining of the canal, or even of the membrane. A sense of *itchiness,* with a feeling of fulness or "stopping up," in the canal of the ear is more frequently present than actual pain.

Consequences. As already mentioned, there are, in many of the cases of accumulated cerumen, other pathological changes in the ear, such as chronic catarrh of the middle ear or disease of the labyrinth. These are probably frequently part of the same morbid process upon which the excessive quantity of cerumen depends. But the morbid changes found in the ear are without doubt sometimes the direct consequences of the pressure exerted by the plug upon the walls of the canal or upon the tympanic membrane. The lining of the walls of the canal may be inflamed and softened, while the tympanic membrane may be thickened, pressed inwards, and even perforated by the long-continued pressure of masses of cerumen. Cases have been observed in which the canal of the ear has been not only widened, but the posterior osseous wall of the canal scooped out, and at several points perforated, the perforations communicating with the mastoid cells.

Diagnosis. The diagnosis of ceruminous obstruction is generally very easy. By the use of the speculum and reflecting mirror, or even by the unaided vision, the mass is seen to completely or partially occupy the external canal of the ear. It is to be noted that the mass may be so packed in upon the membrane as to form a layer on its outer surface which may, if not carefully inspected, be taken for the tympanic membrane itself. Collections of dried purulent masses, coloured with blood or cerumen, or masses of fungi or cholesterine may also be confounded with accumulations of cerumen. The preliminary treatment of these conditions, namely, syringing the ear with warm water, being the same as that for

excess of cerumen, such mistakes are not likely to be followed by injurious consequences.

Prognosis. In only about a third of the cases of deafness associated with plugs of cerumen in the ear is their removal followed by complete recovery of hearing; in another third we find more or less improvement; while in the remaining third the removal of the plugs has no effect whatever. If a deaf patient, therefore, presents himself for treatment, having his ears plugged with ceruminous masses, we must not at once rashly promise a cure. If the deafness came on suddenly, after washing or after a bath, and if good hearing was enjoyed before, the likelihood is that the excessive secretion is the primary and only affection, and that its removal will completely restore the hearing. If, on the other hand, the deafness has come on more slowly, and if the vibrating tuning-fork, applied to the middle line of the head, is heard most distinctly on the unaffected or better side, the probability is that there is another deep-seated and more serious affection, and that the removal of the cerumen will not be followed by restoration or even by improvement of the hearing. The removal of the obstructing masses is, however, the only sure way of solving the question. In some persons these obstructing masses tend regularly to return after months or years.

Treatment of Ceruminous Obstruction. In the removal of ceruminous masses we must trust mainly to the syringe and warm water. If the mass is very hard, or firmly adhering to the walls of the canal, it is necessary to use preliminary softening measures before employing the syringe. A solution, consisting of 10 grs. of bicarbonate of sodium and a drachm of glycerine to an ounce of water, is more effective than the application of oils. A small quantity of this solution, after being warmed, is poured into the ear, and is allowed to remain for from five to ten minutes, this process being repeated several times during twenty-four hours. In cases of extreme hardness of the mass, and when it adheres very tenaciously to the walls of the canal, perhaps through the medium of little hairs, more than one sitting may be necessary before we are able, with the syringe and warm water, to dislodge and completely remove the accumulation. It is well to point out to the patient that the preliminary process of softening may for the time aggravate the deafness and the noises in the ear, owing to the swelling of the mass from absorption of fluid.

Removal with the Syringe. After the softening process the masses should be removed with the syringe and warm water (Fig. 136). If the mass is of a soft nature, the syringing may be at once employed. For a description of the mode of syringing the ear, the student is referred to page 67. While it is important that all the cerumen should be removed, we must not continue the syringing

after the canal of the ear has been emptied. We should therefore examine the interior of the ear in the course of our syringing, so as to stop the operation as soon as we have washed away the whole of the mass.

Sometimes we find the plug covered with a dirty white membrane formed of exfoliated epidermis, while an accurate mould of the outer surface of the tympanic membrane may occasionally be seen impressed on the inner end of the expelled mass. In this case we easily trace an elongated indentation marking the situation of the manubrium, while a slight bulging on each side of the indentation indicates the niche on each side of the manubrium.

FIG. 136.—Mode of syringing the ear.

After the cerumen has been wholly removed, the water should be drained out of the ear, and the canal well dried with cotton wool. For a day afterwards, a plug of cotton wool should be worn in the ear, so as to avoid the evil effects of cold air upon the newly exposed canal and membrane, as well as to protect the organ from the sudden and strong effects of sound, which may for a time be very unpleasant to the patient.

Syringing produces some injection of the blood-vessels of the membrane and of the inner part of the canal, which, however, passes off in a few hours.

Deficiency of Cerumen. This is often found in persons whose skin is dry and hard—the *glandulæ ceruminosæ* sharing in the inactive condition of the sudoriparous glands of the general cutaneous covering. We meet with deficiency of cerumen most frequently in elderly persons who suffer from deafness due to disease of the middle ear, especially that condition known as sclerosis of the mucous membrane. The canal of the ear is then found to be dry, destitute of this natural emollient, and also abnormally wide. In these cases the ceruminous glands after a time become atrophied, or they even disappear altogether. It must be remembered, however, that the cerumen may be deficient simply because it is being constantly washed away by purulent discharge, or being removed by the efforts of the patient in picking the ear, or by frequent syringing.

Symptoms.—The only symptom of deficiency of cerumen is a feeling of uncomfortable dryness in the ear. As has been said, it often co-exists with impairment of hearing; this, however, is not the *result* of the absence of cerumen. The abnormal dryness of the canal may rather be looked upon as an *indication* of disease in the middle ear.

Treatment.—The sense of dryness in the ear may be relieved by painting the walls with vaseline or a slightly stimulating ointment. This has of course no effect upon the hearing. The treatment of the associated disease in the

middle ear is sometimes followed by increase in the secretion of cerumen, which may happen even when no beneficial effect is produced in the hearing power of the patient.

FURUNCULAR OR CIRCUMSCRIBED INFLAMMATION OF THE EXTERNAL MEATUS.

Syn.—Otitis Externa Circumscripta; Boils in the Ear.

Pathology. This painful and troublesome affection has its origin and seat in a gland or hair follicle in the subcutaneous tissue of the external canal of the ear. Like furuncular inflammation in any other part of the body, a boil in the ear is attended by the formation of a core, composed of sloughed connective tissue, or of a necrosed follicle or gland around which there is usually more or less purulent formation. In this way an abscess may form in the subcutaneous tissue of the external auditory canal.

The disease does not often terminate with a single boil; we generally find that there is a succession of them, and that, while one is passing away, another begins to manifest itself. We may find at the same time boils on other parts of the body, especially on the scalp, eyelids, and face.

Causes. Boils in the ear are found most frequently in adults. While the disease may affect persons who are otherwise healthy, being due to an entirely local cause, it is more likely to be met with in those whose general state of health is defective, particularly in those whose digestive functions are badly performed. We may thus meet with the disease in the anæmic woman, or in the *bon vivant*.

Local causes, however, play the most important part in the etiology of the disease. Mechanical irritation, as the use of pointed substances to relieve a feeling of itchiness, may excite the disease. Hence boils are often found where chronic scaly eczema already exists in the cutaneous lining of the external canal of the ear. The prolonged action of pus or other fluid, such as water or ear lotions, upon the skin of the canal, is a very frequent exciting cause of the disease. For this reason, boils in the ear are a common complication of purulent diseases of the middle ear. Solutions of alum seem to be especially liable to set up the disease. The action of cold air or cold water, or of chemical irritants, may also produce furuncular inflammation.

The microbic origin of furunculi in the ear, as well as in other parts of the body, was first enunciated by Dr. Löwenberg of Paris. His discovery of micro-organisms in the contents of the boils has satisfied him that the disease is always due to the invasion and multiplication of special microbes, the staphylococcus pyogenes, aureus and albus (see p. 58). The parasite is derived from either air or water, but especially from the latter, and enters a hair follicle,

where it excites the intense inflammation characteristic of a boil. This view of the disease has modified and guided the course of treatment.

Subjective Symptoms. The symptoms experienced by the patient are usually pain, impairment of hearing, and subjective sounds in the ear. The degree of their severity depends upon the intensity of the inflammatory process, and upon its situation in the canal of the ear.

Pain in the ear may, if the inflammatory process be mild, and if its seat be at the outer entrance of the ear, amount to only a sense of warmth and fulness, or "stopping up." If, on the other hand, the inflammation be more intense, and especially if it be situated in the deeper parts of the canal, so that the inflammatory area has an osseous basis, the pain is usually intensely acute. Patients often describe it as that of a painful sense of stretching, and a distracting beating or "hammering in the ear," worse at night, with occasional intermissions of an hour or two. A sharp pain also frequently radiates over the side of the head. It is aggravated during chewing or speaking, or any other movement of the lower jaw, this being due to the close relationship between the canal of the ear and the articulation of the lower jaw. Pulling the auricle of the affected side, or lying upon it, also aggravates the pain, while incautious attempts to introduce a speculum cause intolerable suffering. The tragus is often especially tender to touch.

In some cases, and particularly when the furunculus is situated on the posterior wall of the osseous part of the canal, the mastoid process may be very painful on pressure, with some œdema, while the auricle may jut out somewhat from the head, thus simulating periostitis of the mastoid process.

Defective hearing is commonly present, and depends upon the extent of the occlusion of the canal by the disease, or upon the amount of concomitant hyperæmia of the middle and even of the inner ear.

Tinnitus aurium, when present, is usually of a humming or buzzing character, and is due either to the causes mentioned as producing the deafness, or to the sympathetic relations between the canal of the ear and the labyrinth.

Febrile disturbance, even delirium, especially at night, may be experienced in irritable systems, or in very severe cases.

Objective Symptoms. In examining the canal of the ear we must use caution and gentleness, employing only the reflecting mirror until we ascertain the position of the boil; if this be found situated in the deep part of the canal, we may then introduce a speculum very gently for a short distance. The attempt to push a speculum into the external auditory canal when a boil is at its entrance will cause the

most acute pain. If the furunculi be connected with middle ear suppuration, the ear should first be gently syringed and dried.

The most frequent position for the furunculus is in the anterior wall of the cartilaginous section of the canal, where it usually forms a distinct rounded bulging. We may find the colour of the bulging little changed from that of the normal skin, especially at the early stage, when the inflammation is mainly in the tissue under the skin. At a more advanced stage, however, the skin over the furunculus is usually distinctly red. The central part of the tumour is very sensitive when touched with the point of a probe. There may be two, or even three furunculi found at the same time closing the meatus, one of them being usually more acute than the others. When affecting the deeper parts of the meatus they are flatter and less defined, but exquisitely sensitive when touched with a probe.

Course and Consequences. The disease sometimes passes off without suppuration or rupture. Much more frequently, however, after from three to five days a reddish, seldom yellowish, spot appears on the surface of the boil, where it bursts, giving exit to some drops of thick pus and to a small flaky mass of sloughed tissue. This latter may require to be helped out by gentle pressure on each side with a probe. Immediate relief usually follows the rupture of the boil. The purulent discharge is generally small in quantity and short in duration, but in certain dyscrasiæ, or where there has been defective treatment, especially the want of proper cleansing, the disease may take a more chronic course. The edges of the opening may then become covered with granulation tissue and exude a thin sanious matter. Only in very rare and exceptional cases, however, does the disease lead to any affection of the underlying bone. It is frequently found that increased formation of epidermic scales and cerumen follows an attack of furuncular inflammation, producing deafness. Hence it is well that the patient should return for examination a month or two after an attack, so that such an accumulation, if present, may be removed.

Diagnosis and Prognosis. Furunculi of the ear may be most readily mistaken for the diffuse form of inflammation of the canal. In the former, however, the swelling is more localized, and the pain, as tested by the probe, is limited to a spot at the centre of the swelling. In the diffuse form of inflammation the swelling is uniform and concentric, while there is also usually much more secretion or epidermic exfoliation than in the circumscribed variety of inflammation. A saccular swelling is sometimes found in the upper and back part of the osseous canal, due to a collection of pus which has made its way through the wall of the canal from the mastoid cells. The history of the case enables us to avoid any error of diagnosis. When there is œdema and pain over the mastoid, the condition may be mistaken for periostitis.

The *prognosis* of this disease is very favourable. It is, however, advisable to warn the patient that several successive boils may form, one immediately after the other, with recurrence, on each occasion, of the painful symptoms, before the disease fully disappears. It is also to be noted that certain persons have regular and periodic recurrence of boils in the ear at intervals of weeks or months.

Treatment of Boils in the Ear. We shall consider this under the three heads of (1) preventive measures; (2) remedies to cut short or to mitigate the inflammatory process; (3) constitutional treatment.

(1) Causes which are known to excite boils in the ear should, if possible, be removed. If a patient is suffering from a purulent disease of the middle ear, we must use means to prevent the constant saturation of the cutaneous lining of the canal with pus, and avoid the prolonged contact of ear lotions, or the too frequent use of the syringe. The canal of the ear must, in short, be kept as dry as possible. This is best done (*a*) by adopting, as far as possible, the dry treatment of purulent diseases of the ear, instead of the use of lotions; (*b*) by the patient wiping away the purulent secretion from the canal of the ear by means of absorbent cotton on a cotton-holder as often as is required, but with great gentleness; and (*c*) by keeping constantly in the ear a cylindrical roll of antiseptic cotton wool, of sufficient size to occupy the greater length of the canal. This cotton plug should be changed as frequently as may be required by the quantity of the secretion. Chronic eczema, or pruritus, of the external canal of the ear, if found to exist, should always be removed by appropriate treatment.

(2) *Incision of the inflamed tissue* is the most effective means of cutting short the inflammatory process. We need not wait till we are sure of suppuration, as, before that stage has been reached, the relief of tension and the free depletion have an excellent effect in allaying the painful symptoms and in cutting short the inflammatory process. The incision should be deep and free, as the chief seat of the inflammation is underneath the skin. A knife with a slender and sharp-pointed blade, such as a fine tenotomy knife, is best suited for making the incision. We should not cut *down* upon the inflamed tissue, but from below upwards, as this is less painful. Afterwards gentle pressure should be used on each side of the incision with a probe, in order to press out the contents of the boil from the opening, and then the ear should be syringed with a warm solution of boracic acid and carefully dried with cotton. Warm poultices of linseed meal may be used for a few hours after the incision, but it is to be noted that the sooner we stop the application of moisture to the canal of the ear the less likelihood will there be of a succession of fresh furunculi. The author has found great benefit from an ointment of 4 grains of iodoform or boracic acid, and 2 grains of

menthol in a drachm of vaseline, thoroughly smeared on cotton plugs introduced into the canal of the ear and changed every few hours. Some prefer carbolic acid and vaseline or glycerine (1 in 50). These plugs should be made so as to occupy the canal of the ear but not to press unduly upon its walls; if they prove uncomfortable the lining of the meatus should instead be frequently painted with the ointment. The instillation of antiseptic solutions, in the recurrent form, is preferred by some—such as boracic acid and alcohol (1 in 20), or bichloride of mercury (1 in 2000). There is little doubt that these have the effect of diminishing the pain and the tendency to recurrence of the boils.

If the treatment by incision cannot be carried out, owing to the aversion of the patient to the operation, or if it is not deemed necessary in consequence of the comparative mildness of the disease, we may employ other remedies to relieve the symptoms. Warmth and moisture are extremely useful in relieving the pain and in hastening the process of softening. These may be applied by means of warm linseed meal poultices, or hot fomentations, which should cover the ear and should be frequently renewed, at the same time the canal of the ear should be occupied by the antiseptic plugs. An ointment consisting of one grain of the hydrochlorate of morphina to a drachm of vaseline has also a sedative effect. For the relief of pain in this and in other painful affections of the ear, Gruber has found great benefit from the introduction into the meatus of medicated gelatine preparations (amygdalæ aurium) containing either $\frac{1}{4}$th grain of liquid extract of opium or $\frac{1}{12}$th grain of hydrochlorate of morphina. After syringing and drying the canal of the ear the gelatine almond is introduced deeply with the aural forceps (Fig. 137) into the meatus,

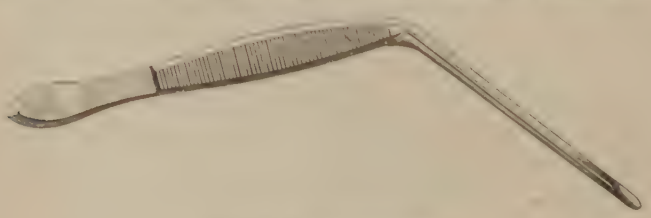

Fig. 137.—Bent aural forceps.

which is then closed with cotton wool. The gelatine gradually dissolves, and relief to the pain generally follows. This should be repeated when required: a half will suffice for children.

If the opening assumes an unhealthy tendency, it should be kept free from secretion by drying with cotton wool, and insufflating finely powdered boracic acid. If granulations arise, they should be removed with forceps or cauterized with chromic acid.

(3) *The general treatment* of the patient, especially in the recurrent form of the disease, is of importance. If any general disease or evidence of malnutrition exist, such as anæmia on the one hand or plethora on the other, we must employ appropriate medicinal and hygienic treatment. In all cases we should inquire after and regulate the diet, the hours of rest, the use of stimulants, exercise, baths, etc. The digestive functions are frequently found to be at fault, and are, as a rule, to be corrected by careful attention to regimen as well as by the judicious administration of medicines. Liquor arsenicalis has been recommended as a specific remedy in persistently and periodically recurrent furunculi in the ear. Sulphide of calcium is said to limit or cut short the disease.

DIFFUSE INFLAMMATION OF THE EXTERNAL AUDITORY CANAL—OTITIS EXTERNA DIFFUSA.

Pathology. The inflammatory process extends over the greater part of the cutaneous lining of the canal, generally, indeed, over its whole extent. It usually also involves the outer layer of the tympanic membrane, while there may be also some hyperæmia of the middle ear. In the severe forms the periosteum lining the osseous part of the canal participates in the morbid process, and in the *hæmorrhagic* form there are bluish swellings in the osseous meatus, which are elevations of the epidermis containing blood. The initial stage of hyperæmia commonly advances to exudation on the surface, and to *abundant epidermic exfoliation.* Croupous and diphtheritic forms have been observed during epidemics of these diseases. In these cases a dirty greyish membrane is seen adhering to the osseous meatus, very difficult of separation, when a bleeding surface is exposed. The membranous deposition found upon the osseous part of the canal is generally associated with a similar condition of the pharynx, although it may, during an epidemic of diphtheria, take place in the canal alone when this has already been affected with inflammation.

Causes. (1) The worst forms of the disease are the results of injury, especially the introduction of irritating substances, the unskilful use of injections, the presence of foreign bodies in the ear or improper or violent attempts to remove them. (2) Many cases are of the nature of *eczema* with copious serous exudation. These may be excited by the use of hard substances to relieve the itchiness attendant upon a chronic scaly eczema of the external meatus. (3) It may arise from disease in the middle ear, especially in the mastoid cells, when, from great swelling and thickening of the lining of the canal, the latter may be almost closed. Affecting the inner section of the canal, it is often a part of an acute otitis media. Syphilis and fungi excite special forms, which will be afterwards separately considered. The diphtheritic is the rarest form of the disease.

Subjective Symptoms. The sensations experienced by the patient vary much in different cases.

The painful sensations are in some very slight, being limited to more or less itchiness, heat, and fulness in the ear. In other cases the symptoms, beginning with these sensations, advance to a dull aching in the ear, which in severe forms, and especially when the osseous part of the canal and the membrane are involved, becomes of an intense and penetrating character, radiating from the interior of the ear over the side of the head. The pain is usually aggravated at night, and may be increased by movements of the jaw or by shaking the head as in coughing, as well as by pressing or pulling upon the auricle. Incautious attempts to introduce a speculum are also attended by acute pain.

The hearing is impaired in proportion to the amount of swelling of the walls of the canal, the quantity of inflammatory products contained in the canal, and the degree in which the tympanic membrane and cavity of the tympanum participate in the inflammation.

Subjective sounds, particularly a sense of pulsation or buzzing, are generally experienced by the patient, and depend on the same causes as produce the impairment of hearing.

General malaise, associated sometimes with distinct feverishness, may be present in the more severe forms.

Objective Symptoms. In the early stage the walls of the canal are seen to be hyperæmic and swollen. The hyperæmia is observed chiefly on the osseous walls of the canal adjoining the membrane. In rare cases hæmorrhagic elevations of the epidermis are seen on the floor of the osseous portion of the canal (*otitis externa hæmorrhagica*). A discharge from the ear appears in two or three days, and, if the process goes on, we find the canal occupied either with serous or purulent secretion, which may be partially dried in the form of scabs, or with laminated masses of sodden epidermis mixed with purulent or serous fluid and swarming with micrococci. These laminated masses are thrown off partly from the skin of the canal and partly from the outer layer of the membrane; they sometimes form almost complete casts of the canal and membrane. On account of them and of the swollen condition of the lining of the canal, there is considerable difficulty in getting a view of the deep part of the canal and of the membrane. We should endeavour to remove these accumulations, which is not always easily done, by cautious and gentle syringing with warm water and careful drying. If we succeed in doing so, the walls of the canal, and generally the membrane also, will be found reddened, swollen, and spongy, while the normal boundary between the walls of the canal and

the membrane will not be distinguished. The cutis, where exposed by recent loss of epidermis, presents a reddish, granular, moist surface.

In the later and *chronic stages* the secretion has usually a very disagreeable smell, and has also an irritating effect on the skin of the auricle. There is more or less congestion, with swelling or thickening of the lining of the external auditory canal, which, especially at its upper and back part, is often covered with brownish crusts emitting a bad smell. Granulations or small polypi are sometimes seen springing from the diseased skin. The tympanic membrane is generally thickened, especially in its outer or cutaneous layer, the vessels of which are often injected, particularly at the upper part. There is in some cases excoriation, or even perforation of the tympanic membrane. We may find glandular enlargements in the neck below the ear, and there may also be more or less swelling of the parotid gland.

Course and Consequences. In very slight cases, or when prompt treatment is employed, the inflammatory process may end in resolution before the stage of exudation. Generally, however, it passes on to exudation and exfoliation, after which the morbid process begins to abate, and the discharge from the ear may come to an end in from one to two weeks, or it may go on to the chronic form. When the disease occurs in a person of a strumous or unhealthy constitution, or when treatment is neglected or of an improper kind, the disease lapses into the chronic form, and, as one form of otorrhœa, may continue for months, or, with occasional remissions or interruptions, for years. When long continued it may lead to the following changes in the canal of the ear or in the neighbouring parts:

(1) There may be contraction of the canal from hypertrophy of the cutaneous lining or from hyperostosis of the osseous walls. (2) Granulations or even polypi may spring from the diseased skin. (3) Caries or necrosis of the osseous part of the canal may result. (4) The tympanic membrane always suffers in consequence of this disease. There may be opacity and thickening, or ulceration and perforation with propagation of the disease to the middle ear. (5) By extension through the osseous part of the roof of the canal there may be fatal implication of the meninges or brain. Or, by propagation of the disease through the upper and back walls to the mastoid cells and thence to the lateral sinus, death may be the result. (6) The disease may extend to the articulation of the lower jaw, especially if gaps exist in the anterior wall, as they do in children; while the parotid gland may be involved through the clefts in the cartilaginous meatus. Some of these consequences will be presently described more fully,

while others will be discussed under the head of "Consequences of Purulent Inflammation of the Middle Ear."

Diagnosis and Prognosis. The points which distinguish the diffuse form of inflammation from the furuncular have already been noticed (see p. 170). In some cases it is very difficult to distinguish it from inflammation of the middle ear, when the latter is attended by swelling of the lining of the inner end of the canal. Further, if a perforation exist in the tympanic membrane, and the middle ear be also involved in the chronic purulent disease, it may be impossible to say whether the disease has primarily affected the middle ear or the external auditory canal.

With proper treatment the prospects of early and complete recovery are very favourable, if the middle ear or bony walls be not involved; even when perforation of the membrane has taken place, it may, under judicious treatment, be quickly healed. Cases having a traumatic origin are the most intractable. Even in the chronic state, if the disease be limited to the cutaneous lining of the canal, careful and persevering treatment will in most cases be crowned with success.

Treatment of Diffuse Inflammation of the External Meatus. In the acute stage associated with severe pain, the treatment described in Chapter XI. for the early stage of purulent inflammation of the middle ear is suitable.

When the stage of secretion and epidermic exfoliation has been reached, the inflammatory products contained in the canal of the ear should be removed by cautious and gentle syringing with a hot solution of boracic acid or a two per cent. solution of carbolic acid. This is very soothing to the patient; but forcible syringing will excite pain and may cause perforation of the membrane. After syringing, the interior of the ear should be carefully dried by means of absorbent cotton on a cotton-holder, and a small quantity of finely powdered boracic acid blown in. This is to be removed by syringing when it becomes saturated with the secretion, and a fresh application made. As soon as the secretion has ceased to form, the ear should be finally syringed and the parts simply kept dry. When the lining of the walls of the canal is much thickened from an eczematous form of inflammation, a strong solution of nitrate of silver (forty grains to the ounce of water) should be painted over the walls of the canal by the surgeon several times, at intervals of three or four days. This has a very beneficial influence upon the thickened cutaneous tissue. Similar treatment is very suitable for dry scaly eczema which often continues after an acute attack has passed off. After the use of nitrate of silver, a ball of cotton soaked in a solution of common salt should be inserted in the orifice of the ear for a minute to prevent blackening. Polypi and

granulations are most efficiently and quickly treated by removing them with Wilde's snare or with forceps, and afterwards employing the spirit treatment (see p. 89). The treatment of the other complications and consequences of chronic otitis externa will be found under their own proper headings.

Constitutional treatment is useful when the disease occurs in weakly or strumous persons, although local treatment is always of the first importance. Iron, cod liver oil, nutritious and digestible food, plenty of fresh open air, etc., have often a determining influence upon the favourable issue of the disease.

STRICTURES OF THE EXTERNAL MEATUS DUE TO INFLAMMATORY AFFECTIONS.

Varieties of Stricture of the External Meatus. (1) *Swelling or thickening of the cutaneous lining* may so contract the canal of the ear as scarcely to allow of the admission of an ordinary probe. Its most frequent causes are (*a*) chronic eczematous inflammation, when it mainly affects the outer part of the canal, or (*b*) chronic otitis externa, either primary or arising from purulent inflammation of the middle ear; the latter is more frequent, and hence there is usually discharge from the middle ear. The cautious use of the probe will show the degree and length of the narrowing.

(2) *Septa or adhesions* may be due (*a*) to the coalescence of granulation or polypoid tissue, (*b*) to the long-continued contact of abraded surfaces which have been brought into apposition by thickening of the cutaneous lining, or (*c*) to ulceration from the effects of burns, caustic substances, syphilis, etc. There may be a complete membranous partition, which, if situated far in, may be mistaken for an altered tympanic membrane; or a septum in the form of a ring with a central aperture may be found. A considerable extent of surface may be adherent, and the closure may even become bony. The degree of deafness varies according to the thickness of the septa or the breadth of the adhesions. The probe should be employed to determine the situation and nature of the closure.

(3) *Hyperostosis of the meatus* consists of a diffused thickening of the whole extent, or of a great portion, of the osseous part of the external canal, producing a uniform contraction of its lumen. The bony surface may be smooth, but more frequently it presents small rough elevations. The skin of the canal is generally reddish and swollen or even thickened. It may usually be looked upon as a chronic periostitis, with increased formation of osseous tissue; and it is very frequently associated with, or a sequela of, chronic purulent disease of the middle ear. After the removal of a sequestrum from the posterior wall of the canal, thickening and hypertrophy of the osseous tissue some-

times take place, which may almost totally close the canal. A similar condition of osseous hypertrophy may exist at the same time in the walls of the tympanum and of the mastoid cells adjacent to the external canal of the ear. Hyperostosis is sometimes, however, found in connection with non-purulent catarrh of the middle ear. The defective hearing which generally exists is due rather to the presence of secretion in the canal, or to concomitant disease of the middle ear, than to the mere thickening of the walls. The contraction of the lumen of the canal, caused by the uniform thickening of the osseous walls, may lead to serious consequences in cases where purulent disease of the middle ear co-exists with it. If the contraction becomes so extreme as to prevent the escape of purulent secretion from the middle ear, dangerous retention of pus may ensue, and the opening up of the middle ear through the mastoid process may require to be undertaken in order to save the life of the patient.

Hyperostosis is distinguished from exostosis by the distinctly circumscribed form of the latter as compared with the diffused uniform thickening of the former.

Treatment of Strictures of the External Meatus. When due to cutaneous swelling or thickening, in the event of there being a discharge from the middle ear, gentle syringing with a warm solution of boracic acid, with subsequent careful drying of the walls of the canal and the introduction of diluted spirit, should be carried out. After each application a long cylindrical plug of cotton wool, smeared with an ointment composed of 4 grains of iodoform to a drachm of vaseline, is inserted by means of a cotton-holder and is changed morning and evening. Along with the treatment of the middle ear, comparatively slight and gradual pressure with the cotton plug often effects great improvement. If the canal is not sufficiently widened in this way, a thin compressed sponge tent should be used. The tent must not be allowed at first to remain in the ear more than two hours, during which the patient should be close at hand so that the surgeon may himself remove it. At intervals of two or three days such tents may be introduced with good effect. Severe and rapid dilatation must be avoided. In cases of purulent secretion retained in the deep parts, after dilatation with the tent a small conically-shaped vulcanite or soft rubber tube should be inserted and kept in; this maintains the dilatation, allows escape of the secretion, and permits of syringing the ear. If there be great and unyielding thickening of the walls, repeated longitudinal incisions may be tried, followed by plugs of cotton or sponge tents. In the dry scaly thickening of eczematous conditions, a plug of cotton wool saturated with a solution of nitrate of silver (40 grs. to the ounce), should be inserted for a few

seconds and then neutralized by a solution of common salt. A plug of cotton smeared with a slightly stimulating mercurial ointment (see *Ointments* in list of Formulæ), should afterwards be worn in the ear.

If a *septum* be found in the meatus it should be removed by a circular incision, and a cotton plug worn in the ear for some time afterwards. If there be *adhesions* of surfaces, careful separation with a fine-bladed knife may be attempted, followed by the use of sponge tents or cotton plugs.

In an *elongated osseous stricture* good may be done by removing epidermic or ceruminous accumulations, which are liable to form. If a purulent discharge exists, whether its source be in the middle ear or in the external auditory canal, this must be carefully treated. Thickening of the cutaneous lining of the canal is to be dealt with as already described. The cautious use of sponge or laminaria tents, in order to produce a gradual mechanical pressure upon the osseous growths, may be followed by an increase in the width of the canal, after which treatment directed to the removal of the disease in the middle ear can be more effectively employed. The sponge tent is to be preferred on account of its being more gradual in its action; excessive and rapid pressure on the walls may do much harm. If symptoms of retention of pus in the middle ear show themselves we must not hesitate to open the mastoid antrum and remove the posterior wall of the canal (see p. 91).

Congenital Contraction. The canal of the ear may be altogether absent, or it may be so narrow that the most slender probe cannot be introduced. In these cases there is usually also a congenital defect of the auricle, as well as of the middle ear and sometimes of the labyrinth, so that the endeavour to form an artificial canal is rarely successful in giving better hearing. If, as in some cases, there is simply great contraction of the cartilaginous part of the canal from congenital causes, persevering efforts to dilate this portion by laminaria or sponge tents may have good results.

In some persons we find that the antero-inferior wall of the middle part of the osseous canal projects so much towards the lumen, that only the upper and back part of the membrane is visible. The only inconvenience of this abnormality is the hindrance which it presents to examination of the membrane or to operations upon it.

Collapse of the Meatus. This is found chiefly in persons of advanced age, and is caused by the approximation of the posterior to the anterior wall at the entrance to the ear. This approximation is probably due to an over-flaccid condition of the fibrous tissue and skin which form the upper and back walls of the cartilaginous canal. The entrance to the ear may in this way be reduced to a mere slit. This rarely interferes with the acuteness of hearing; but if it does so, the patient should employ a small silver tube of the same shape as, but rather smaller than, an ear speculum. This is to be kept in the ear only on occasions when it is important that the patient should hear. As has been already mentioned, accumulation of cerumen is likely to take place in this condition, owing to the hindrance to its normal removal from the ear.

EXOSTOSES OR OSSEOUS TUMOURS IN THE EXTERNAL MEATUS.

These appear as hard, rounded tumours of very various sizes, with circumscribed bases, projecting from the osseous walls of the canal of the ear (Figs. 138 and 139). They are of two kinds, namely,

FIG. 138.—Two globular exostotic growths at the inner end of the external auditory canal—right ear. *a*, Larger, coming from antero-inferior wall; *b*, smaller, coming from antero-superior wall; *c*, tympanic membrane behind upper part of manubrium.

FIG. 139.—Exostosis springing from roof of external meatus. A, Exostotic growth.

those which have a pedunculated attachment, and those which are sessile and attached by a broad base. The latter are often multiple, very hard, and terminate in apices which may meet in the centre of the canal. These tumours are generally composed either of compact or spongy bone, but occasionally they are hollow.

Causes. Exostosis is met with more frequently in men of middle age who eat and drink generously; and Toynbee believed the disease to be connected with the gouty or rheumatic diathesis. Heredity has also probably a predisposing influence in the causation. Those which are found in both ears, in the inner end of the osseous meatus, and which rarely go on to closure, probably originate in the process of ossification. The growths may be found associated with chronic non-purulent catarrh of the middle ear; but there is no doubt that a considerable number originate in irritative or inflammatory processes in the external auditory canal, usually secondary to chronic purulent inflammation of the middle ear. In such cases it is supposed that there is first of all periosteal thickening, or a small abscess in the external auditory canal, with granulation tissue; and that the granulation tissue is gradually converted into bone by a process of ossification extending from the base. It is significant that a large proportion of cases have their origin in the posterior or mastoid wall of the canal—a situation more prone than any other, owing to its relation to the mastoid cells, to inflammatory and purulent processes. That the frequent entrance of water into the canal of the ear is an important factor in the causation of these growths is pretty well established.

As bearing upon the etiology of these bony growths in the canal of the ear, we may refer to the remarkable observations by Blake, of America, upon the crania of the mound builders of the Cumberland valley of Tennessee, and of Seligmann in regard to the crania of the Titicacas. Out of 195 crania of the

mound builders examined by Blake, an exostosis in one or both canals was found in 18 per cent., and these were in most cases on the posterior walls. The most likely explanation of this remarkable prevalence is that these aboriginal inhabitants of America, living as they did on river banks, were frequently in the water, the irritation caused by the entrance of water being probably the exciting cause. Aural exostoses are very common among the South Sea Islanders who are, in many cases, almost amphibious in their habits, and are notable divers, remaining under water for prolonged periods. Their ears are thus frequently full of sea water at varying degrees of temperature and pressure. The observations as to this frequency of aural exostoses include chiefly the Fijian and Hawaiian Islanders. Other groups of islanders have not yet been investigated.

Symptoms and Course of Exostoses. These growths are usually very tender when touched with a probe. If the lumen of the canal be completely filled up there may be intense pain, due to the pressure of the expanding growth on the walls of the canal. If they have not developed to so great an extent as to close the canal, the patient has rarely a feeling of anything being wrong, and the presence of an exostosis may be first ascertained, when deafness, produced by epidermic or ceruminous accumulations, brings the patient to the surgeon for advice. Or he may first ask the aid of the surgeon in consequence of the symptoms produced by a co-existing middle ear disease. When the exostosis has completely closed the canal, the deafness is, of course, very considerable or even complete.

We may find several of these growths in the same ear, and not unfrequently they are present in both ears of the same person. They appear as knob-like projections, often of ivory hardness when touched with the probe, generally of a pale colour, but sometimes slightly red. If they be large, so as almost to close the passage of the ear, the skin over them may be thickened and spongy, and of a reddish colour. The surface is generally quite smooth. They may appear at any part of the canal, but the pedunculated variety is more frequently met with coming from the back wall, especially at the junction of the cartilaginous and osseous portions of the meatus. In that situation also they generally lack the ivory hardness of those multiple ones situated in the deeper parts of the meatus. We sometimes see two or three conical growths springing from opposite walls with only a fine opening between their apices.

The growth of these tumours usually extends over a long period of time. They sometimes, however, go on quickly to complete closure of the canal; or, on the other hand, after having reached a certain size, they may become quite stationary.

Diagnosis and Prognosis. Their hardness, comparative paleness, and circumscribed form usually distinguish them from any other morbid growth in the canal of the ear.

In very many cases they never develop to such an extent as to produce serious inconvenience. Sometimes the cutaneous lining becomes inflamed and swollen, and there may even be granulation tissue occupying the chink. If the canal be completely closed and if the growth cannot be removed, there is not only great impairment of the hearing, but there is always the possibility that, in the event of a purulent disease affecting the middle ear, a fatal issue may arise from retention of the purulent secretion.

Treatment of Exostoses. If there be epidermic or ceruminous accumulations these must be regularly and carefully removed: this may often postpone operative treatment indefinitely, even when the lumen of the canal is reduced to a fine chink. If a small elastic tube can be introduced between the tumour and the opposite wall of the canal, the cleansing of the deeper parts is much facilitated. Appropriate treatment should be employed if there be a swollen or thickened condition of the cutis, and the cautious introduction of the antiseptic cotton plugs as in the treatment of strictures (see p. 178) should be tried. If there be granulation tissue at the chink, its removal may be followed by much better hearing. In the event of a purulent discharge from the middle ear appropriate treatment should be adopted (see Chapter XI.). No operative treatment is to be adopted when the tumours are small and do not completely close the canal of the ear. Even when the canal is completely closed by these osseous growths, operative measures are not in all cases to be undertaken. Only when, owing to loss of hearing in the other ear, total deafness exists, or when dangerous symptoms due to retention of secretion in the middle ear manifest themselves, is operative treatment demanded.

Methods of Operating. There are several recognized methods of operation. (1) In those somewhat less dense growths having a narrow pedicle and associated with purulent discharge from the middle ear, *a cold steel or an electric snare*, if it is possible to introduce a wire and encircle the growth, may, by combined penetration and traction, be sufficient to remove the exostosis. A general anæsthetic is necessary. The author once removed an exostosis having a slender pedicle (Fig. 140, *b*), by encircling it with a steel wire attached to a Jarvis' nasal snare. In another case, with a thicker pedicle, he was able by means of a galvanic snare to remove an exostosis (Fig. 140, *c*) which closed the canal and brought about retention of purulent secretion. When it is possible to introduce a wire

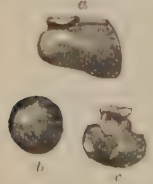

FIG. 140. Exostoses removed by author: *a*, removed with burr after displacement of auricle; *b*, removed with cold-steel wire loop; *c*, removed with a galvanic snare.

loop, this method should be tried before resorting to other more difficult operative treatment. In these varieties, also, fine but strong dentists' forceps have been successfully employed. (2) The operation with the *drill* or *bur*, propelled by a dental engine, through the external meatus, has been extensively practised during the last twenty years. This method was introduced by Dr. Mathewson of New York, and is much practised and advocated by Field and Dalby. Dalby uses a drill propelled by an electro-motor, with which he gets much greater speed and is thus, he asserts, able to grind the bone away with a minimum of pressure and therefore with less danger of the drill slipping. Field prefers the ordinary mode of foot propulsion. The tragus should be held well forward by a suitable instrument in the hands of an assistant. If a fine steel guard can be introduced behind the growth, which is, however, not often possible, the bur can be worked with greater safety. A variety of burs and drills should be at hand to meet the various contingencies. The patient should be placed on a table four feet high, and a source of light suitable for a reflecting mirror on the operator's forehead should be provided. If the growth be near the orifice no speculum may be necessary; if required, the speculum should be as short and wide as possible. The bleeding is usually troublesome, and necessitates constant mopping out with absorbent cotton, which much prolongs the operation. Dalby alleges that, since he has begun to use the electro-motor, he has not been troubled with bleeding, as the heat caused by the rapid movement of the drill coagulates the albumen of the blood and thus prevents bleeding. In the multiple ivory growths, conical in shape with broad bases, their apices should be carefully ground away till a sufficiently large canal is made. If the growth be large and round, tightly closing the meatus, it may first be perforated with a small drill and the perforation gradually enlarged. After gentle syringing with an antiseptic solution, a quantity of the powder of iodoform and boracic acid (1 in 4) is blown into the meatus, and a narrow strip of iodoform gauze is introduced. The regular use of cotton plugs, smeared thickly with iodoform and vaseline ointment, keeps the lumen of the canal open till the healing process is complete.

Operation by Displacement of the Auricle. When the growth is found in a very narrow meatus, it is better and safer to undertake the operation first performed by Knapp (and afterwards by Bezold and others), namely, separating the auricle and cartilaginous meatus from behind; in this way the bony growth is exposed for safe manipulation. An incision from 1 to $1\frac{1}{2}$ inches in length is made behind the auricle at its junction with the mastoid. All the tissues down to the bone are severed and drawn

forward so as to expose the posterior edge of the osseous meatus, where the bony growth is usually situated. The growth is carefully denuded of its lining membrane. A small bur is then applied to its base, which is now under complete command, and, with the aid of the dental engine and bur, it is slowly but safely penetrated and removed. The auricle is then replaced and the wound accurately sutured. The meatus is afterwards treated in the same way as in the operation through the meatus. In a case operated on in this way by the author (Fig. 140, *a*), the wound behind the auricle healed by first intention, and the hearing power, which had been almost entirely lost, was restored.

Operation through the external meatus with the *chisel and mallet* may be adopted when there is reason to believe that the pedicle is slender, and that a gentle tap or two of the mallet will be sufficient to bring it away. If, however, the auricle is first displaced forward and the growth freely exposed, as just described, the chisel and mallet may be employed with greater safety and efficiency. When the chisel is applied, as Knapp suggests, to the bone rather behind the base of the growth, so as to chisel out a portion of the osseous wall itself, this method is then still more safely carried out, although the maximum of safety is probably secured by the use of the bur after displacement of the auricle.

SYPHILITIC DISEASES OF THE EXTERNAL MEATUS.

In the form of condylomata or ulceration, syphilis is occasionally found in the external meatus, especially near the outer orifice. These belong to the secondary symptoms of syphilis, and are usually associated with a syphilitic throat affection. Condylomata at the outer orifice of the ear are, however, sometimes met with during the primary stage of syphilis. The condylomata usually occupy the outer orifice of the ear, appearing as a greyish-red mass of granulation tissue yielding a fetid discharge. A small opening is found in the centre of the mass leading into the canal of the ear. Diffuse otitis externa is generally excited, causing considerable swelling of the walls of the canal, and, in some cases, pain of an intense, radiating character. Syphilitic ulcerations of the external auditory canal are usually circular in shape with thickened edges and they have a dirty white appearance. Both the condylomata and ulcerations are apt to leave patches of pigment or cicatrices, and the cicatricial tissue may seriously contract the lumen of the canal.

Treatment. We must of course employ general antisyphilitic treatment (see General Remedies in list of Formulæ). Great attention should be given to local cleanliness by frequently syringing the ear

with warm water containing a disinfectant. If long and ragged, the condylomata should be cut off with scissors, and chromic acid afterwards applied several times. Dusting the masses occasionally with calomel powder also helps to bring about their disappearance. The ulcerations should be treated by the daily application of tincture of iodine for a time. An ointment, composed of 10 grains of iodoform to an ounce of vaseline, forms a useful application in addition to cauterization.

FUNGI IN THE EXTERNAL MEATUS (OTOMYCOSIS).

Schwartze and Wreden were the first to direct attention to symptoms, similar to those of otitis externa, produced by the growth and accumulation of certain fungi, generally belonging to the *genus aspergillus*. These fungi are usually most developed in the inner third of the canal and on the outer surface of the tympanic membrane.

Causes. These fungous masses are chiefly met with in an external meatus where there has previously been disease which has led to accumulations of epidermis, these seeming to form a nidus for the germination and growth of the parasite. A profuse purulent secretion is unfavourable to the life of the fungi. They are most frequently found in the male sex. Oil poured into the canal of the ear, and allowed to lie and become rancid, is said by Bezold to favour their development, and damp dwellings have probably the same effect. Judging from German writers and from its rarity in this country, it is not so common a disease in Britain as in continental countries.

FIG. 141.—Aspergillus nigricans. *g*, Gonidia; *h*, hyphæ; *m*, mycelium; *r*, receptaculum; *s*, spores; *t*, sterigmen (Urbantschitsch).

Symptoms and Consequences. The symptoms are usually pain, impairment of hearing, and some form of tinnitus aurium. The pain may be slight, but it is more often severe. Fungi have been found to exist in the external meatus, without producing symptoms. Apparently only when they penetrate beneath the epidermis, especially in an already unhealthy meatus, do they excite inflammation. The accumulations in the ear are usually of a blackish colour from the spores of the *aspergillus nigricans* (Fig. 141). In this variety the

heads of the hyphens appear as small black points. When, on the other hand, the fungus belongs to the variety *aspergillus flavescens*, the collections are whitish or greyish, the heads of the hyphens forming yellowish points. Microscopically these fungi are found lying between and covering the epidermic scales. They adhere very tenaciously to the tympanic membrane and to the inner parts of the walls of the canal. When they are removed the cutis beneath is found to be reddened, thickened, and sometimes has a tendency to bleed.

These masses are very likely to maintain a condition of chronic otitis externa, exciting occasionally acute exacerbations of the inflammation. Their presence may also lead to serious injury to the walls of the canal and the tympanic membrane. If imperfectly treated, and the fungus is not thoroughly eradicated, there is a great tendency to relapse.

The disease is apt to be confounded with accumulations of cerumen. When collections in the canal of the ear are attended by great pain, we may suspect this disease. Microscopic examination is, however, the only means of arriving at a certain diagnosis. The *prognosis* is very favourable when we are aware of the precise nature of the disease.

Treatment of Fungi in the Ear. We should first use the syringe and warm water medicated with carbolic or salicylic acid or permanganate of potash till we succeed in completely removing the masses contained in the ear. The syringing often requires to be repeated several times with, occasionally, the aid of forceps, before this is effected. After this has been done it is essential, in order to prevent the regrowth of the fungi, to introduce some more decided parasiticide. Various forms of these may be employed. Either rectified spirit of wine, diluted with water at first to avoid exciting pain, or an alcoholic solution of bichloride of mercury (1 gr. to the ounce) will eradicate the fungus. Either of these, after having been warmed, is poured into the ear, and allowed to remain there for ten minutes at a time—this process being repeated several times a day for a week. Carbolized or salicylic cotton should be used for stopping the ear.

EPITHELIOMA OF THE EXTERNAL MEATUS.

The external meatus is usually the starting-point, in the author's experience, from which epithelioma afterwards extends to the whole organ of hearing, to the glandular structures in the neighbourhood, to the facial canal, and to the interior of the cranium. The earliest sign of the disease is that which to the eye seems to be an eczematous abrasion or a ruptured furunculus on the floor of the cartilaginous

meatus; this goes on to slight ulceration, with surrounding swelling and induration, and involves after a time the glands immediately below the auricle, the tragus, and the mastoid tissues. Fetid discharge constantly escapes, while unhealthy looking granulation tissue may sprout from the eroded surface. Intense and continuous pain, usually preventing all sleep, is the chief subjective feature of the disease. The remedies which usually benefit simple inflammatory conditions have but little influence on the pain, or on the purulent discharge and swelling. In an inward direction as well as in an outward, rapid extension of the swelling, with induration and ulceration, takes place, till a large part of the interior of the temporal bone may be exposed. Facial paralysis shows itself, followed sooner or later by meningeal or cerebral symptoms, terminating in death after from one to two years from the beginning of the malady.

Treatment of Epithelioma of the Ear. The disease has usually progressed too far, before it comes under observation, to admit of operative treatment. A comparatively slight erosion of the canal with thickening, when accompanied by great and persistent pain continuing for weeks, should excite our suspicion, and at such an early period thorough excision of the disease might be possible. Otherwise, antiseptic cleansing, with soothing local and general remedies, comprises the treatment.

CARIES AND NECROSIS OF THE EXTERNAL MEATUS.

Caries and necrosis of the osseous part of the external auditory canal are most frequently caused by purulent inflammation of the middle ear, and especially of the mastoid cells. In the latter case the upper and back parts of the inner end of the osseous canal are most frequently affected. The diffused form of otitis externa, either primary or secondary to purulent otitis media, is less frequently the cause of caries or necrosis.

The symptoms are usually those of purulent disease of the middle ear, or of the external meatus. There is sometimes, however, very severe pain, especially when there is a sequestrum.

The probe is the only certain means of distinguishing caries or necrosis. In the former we feel the softened carious spot, or the probe may pass through a carious aperture into the mastoid cells. In necrosis the rough necrosed bone, attached or loosened, is easily distinguished. Usually at the seat of the diseased bone we find exuberant granulations, which often bleed when touched. These granulations, if removed, immediately form again, and may indeed fill the whole canal. At a carious spot we sometimes find, instead of granulations, a cutaneous ulcer with inflamed edges. In caries

due to disease in the mastoid cells the cutaneous and periosteal linings of the walls of the canal, especially of the posterior wall, may be very much swollen or thickened, rendering an examination of the deeper parts of the canal difficult.

When affecting the inner end of the upper wall of the canal, the head of the malleus and the body of the incus may be exposed in the region of the membrana flaccida.

The course is usually a very lengthened one, especially in persons of defective constitution. The prognosis is favourable in necrosis, ultimate recovery usually following the separation and removal of a sequestrum. In caries operative treatment generally brings about a cure.

Treatment of Caries and Necrosis. The otitis externa, or the purulent disease of the middle ear, must be treated. In necrosis, after waiting till the sequestrum separates, we should remove it with strong forceps if syringing be not sufficient. (See Treatment of Caries and Necrosis of the Middle Ear.)

If there be a soft bulging in the upper and back part of the canal, it should be incised, when probably a carious communication with the mastoid cells, or a necrosed part of the bone, will be found. A carious part, if unconnected with disease in the mastoid cells, may be safely scraped with a small sharp spoon; and, if this is followed by the insufflation of iodoform and boracic acid, a good result may be expected.

Necrosis or caries is sometimes followed by stenosis of the canal. This must be guarded against by measures suitable for dilating the canal (see p. 178).

FOREIGN BODIES IN THE EAR.

Foreign bodies in the ear are generally seen in children. They are very diverse in nature, size, and shape, including such bodies as beads, peas, small buttons, small stones, stones of fruit, pieces of paper, bits of bread, small pieces of slate pencil, or of wood, etc. They may get into the ear by accident, or they may be pressed into the external meatus by children in play.

Symptoms of a Foreign Body in the Ear. In whatever way a foreign body may get into the ear, the kind of phenomena called forth by its presence depends upon its size, its shape, its chemical and mechanical nature, and upon the force used in introducing it. A small, smooth, round body, for example, such as a bead, may lie in the canal of the ear for almost any length of time without exciting any morbid sensation. Most aural practitioners know of cases of small bodies remaining for many years without provoking any irritation. On the other hand, if the object be larger, and if

it happen to have been pressed deeply, and with great force, into the ear, either at its admission or by subsequent efforts to extract it, serious symptoms and consequences may ensue from the pressure, and injury may be inflicted upon the walls of the canal or upon the tympanic membrane.

When the foreign body simply occupies the lumen of the canal, exerting but slight pressure on its walls, the *subjective symptoms* produced by it will probably be limited to some degree of deafness, and more or less tinnitus aurium. If the object be larger, and if it be forcibly pressed deeply into the canal of the ear, or if it be a smaller object, but of a vegetable nature, such as a pea, which after admission has become larger by the absorption of fluid, pain of greater or less severity will be excited. If the pressure upon the walls of the canal be still greater, and, particularly, if the foreign body also press upon the tympanic membrane, the pain may be intense, partly from the otitis externa, or otitis media, excited by it. Many unfortunate cases have been recorded of more serious symptoms still, leading even to fatal consequences. There can be little doubt that these have been more frequently due to the injuries inflicted by the improper use of instruments, than to the undisturbed presence of the foreign body.

Peculiar *reflex phenomena* in other organs have occasionally been observed in connection with foreign bodies in the ear. These are to be explained by the mechanical irritation exercised upon the numerous nerve twigs from the trigeminus and the vagus, which are distributed in the cutaneous lining of the external meatus and tympanic membrane. Thus cases are recorded of persistent cough, epileptiform attacks, giddiness, vomiting, constant sneezing, etc., due to the presence of foreign bodies in the ear, the removal of which was attended by the disappearance of these symptoms.

The Foreign Body should be seen. When a person comes before the surgeon, stating that a foreign body has got into his ear, the first point to determine is, whether the ear *really contains* such a body, for cases have come under the observation of most aural surgeons, in which the ear has been injured by the use of instruments, when a careful examination would have shown that no such body existed in the ear. A small round object which has gone into the ear, without being actually pressed into it, may pass out again. Hence, before the patient comes to the surgeon, the object may have dropped out of the ear during sleep, or during some movement of the head, quite unnoticed by the person. The author has seen a case in which the outer edge of the tympanic plate was broken off by forceps employed with great force, under the impression that a pin, believed by the patient to be in the ear, was being grasped.

The medical man had, unfortunately, not inspected the ear, and as a matter of fact there was no pin there. Such a possibility makes it necessary that *the statement of the patient should always be tested by inspection with the reflecting mirror and speculum.* We must never trust to the sense of touch given by a probe, introduced into the canal of the ear, without the aid of the eye and of thorough illumination of the interior. The sensation given by the contact of the point of a probe with the osseous walls of the canal, or with the malleus, may easily deceive the examiner into the opinion that he is touching a hard foreign body in the ear.

In most cases we are able at once to view every part of the interior of the ear where a foreign body can lie, with the aid of the reflecting mirror and speculum. If, however, there has been a pre-existing perforation in the tympanic membrane, the foreign body may have passed into the tympanic cavity, and may thus have escaped beyond the reach of vision. Or the walls of the canal may be so much swollen by inflammatory reaction, that the object is rendered invisible. In either of these cases the cautious use of the probe, while the interior of the ear is illuminated, will usually remove any doubt. The foreign body may be covered with cerumen and only be found after syringing.

The object, if a small one, may be hidden from view in the *sinus* of the external auditory canal. This in some persons is so deep that we are unable, by any methods of examination, to see the bottom of it. If the patient reports that a small foreign body is in the ear, and if, on examination, no such body can be seen, we should, if unable to get a complete view of this sinus, syringe the ear two or three times with warm water. If there really is a foreign body, we shall find either that it is washed out of the ear by the syringing, or that it has been so displaced by the injected water that it is brought into view when we again inspect the interior of the ear.

Or, lastly, a small sharp object, when embedded in the skin of the external auditory canal, may be readily overlooked if the walls of the canal be not thoroughly scrutinized.

Treatment of Foreign Bodies in the Ear. Having assured ourselves that a foreign body *is* present, we have next to decide upon the best and safest methods of removing it. Before describing these methods in detail, it may be well to mention a few general points, which should be kept in view by the surgeon. (1) Most of the foreign bodies which find their way into the ear (such as small beads, small round stones, tiny bits of bread or of paper, and such like) are much smaller than the lumen of the canal, and do little harm by their presence. In such cases the patient

and the friends, who are often very much excited, should have their minds calmed by the assurance that a little delay in the removal of the foreign body will do no harm. (2) The immediate resort to instrumental or operative interference, when a foreign body is in the ear, irrespective of its size, position, or nature, must be earnestly deprecated. The presence of a foreign body is, in the great majority of cases, much less injurious than attempts to remove it by instruments in the hands of those little accustomed to aural work. (3) If the canal of the ear is found to be intensely painful, and its cutaneous lining in a state of acute inflammation from the irritation of the foreign body, or, what is more likely, from the efforts made to remove it by means of instruments, we should employ remedies to remove the pain and the inflammation before we attempt to extract the foreign body. (4) If instruments be necessary, the surgeon should be extremely gentle and cautious in their use. The interior of the ear must be properly and thoroughly illuminated by means of a reflecting mirror fixed to the forehead, so that in his manipulation every movement of his hand may be guided by the eye. An anæsthetic should be administered if the patient be a child or a nervous adult.

Removal of Foreign Bodies by Syringing. For small objects which neither fill the lumen of the canal, nor exert any pressure on its walls—and these as we have already seen are the most common—the treatment is simple, safe, and effective. This consists in the proper use of the syringe and warm water (see p. 67). A few well-directed streams of warm water will soon be followed by the expulsion of the body.

The syringe used should have a slender nozzle which, during syringing, must be directed towards the gap between the wall of the canal and the foreign body. The addition of soap to the warm water makes it more easy to move the body from the position it has taken up. While syringing, the auricle is to be pulled upwards and backwards with the left hand so as to remove the curve of the canal as far as that is possible. The head of the patient should also be inclined downwards towards the side to be syringed, in order that, by making the floor of the external auditory canal an inclined plane, the movement of the object outwards may be assisted. When the water is in this way injected behind the foreign body, the latter will be gradually urged by the pressure of the fluid towards the external orifice of the ear. After it has reached the outer orifice, if it does not drop out, it may be easily and safely removed.

If the foreign body is a vegetable substance, such as a bean or pea, and the treatment by syringing be employed, we must be

prepared to remove it at one sitting. If we allow some time to elapse, after injecting warm water, the pea or bean will swell from absorption of fluid, and it will thus become more firmly impacted, and will be much more difficult to remove. It is said, however, that if rectified spirit be used after syringing the swelling may be prevented.

Impaction of a Foreign Body in the Ear. When we have to deal with a larger body, which may have been pressed forcibly into the ear, and which is firmly embraced by the walls of the canal, there is greater difficulty in its removal.

The degree of difficulty will depend, first, upon the situation of the foreign body with respect to the *isthmus*, which is that part of the canal where there is usually a considerable bulging of the floor, causing a well marked narrowing of the lumen. Between this projection and the tympanic membrane there is a gradual sinking of the floor, forming the *sinus* already referred to. If the foreign body be *outside* of the isthmus, its removal is generally easy, either by means of the syringe used under the conditions which are about to be stated, or by some one of the instruments which we shall afterwards describe. *The greatest care must be taken in order to prevent the foreign body being forced from this favourable position to a part of the canal beyond the isthmus.* If it has been forced beyond the isthmus into the sinus of the canal, its removal is very much more difficult, and may require the most skilful manipulation. The difficulty is rendered still more formidable if the foreign body has become tightly fixed in this position either by the swelling of the object, if of a vegetable nature, or by inflammatory swelling of the cutaneous lining of the canal. Secondly, the degree of difficulty will also depend to a considerable extent upon the presence or absence of a gap between some part of the foreign body and the walls of the external auditory canal. The lumen of the canal being oval in shape, and foreign bodies being often round, there is frequently such a gap, the exact situation of which should be carefully ascertained by inspection, in order to direct the stream of water through it when syringing the ear. If this precaution be neglected, the stream of water, instead of expelling the body, may drive it further in.

The Instrumental Removal of Foreign Bodies. If, after a fair trial with the syringe, we fail to move the body outwards, some form of instrument will be necessary, either to extract it, or to so displace it that subsequent syringing may be more successful in bringing it away.

Ordinary forceps must be discarded as being very likely to force the foreign body further into the canal of the ear.

A very thin slightly curved instrument, used as a lever, is useful,

and, with the precautions already mentioned, is quite safe. Such an instrument (Fig. 142) was introduced by Sir Joseph Lister many years ago.

The forceps suggested by Dr. Guye, of Amsterdam, and shown in the woodcut (Fig. 143), are of great service. The instrument consists of two branches, which are made to fit into, and move on, one another by means of a pivot. The ends of the branches resemble the blades of midwifery forceps in miniature. These fine small blades are introduced separately on each side of the foreign body, and, the two branches of the forceps being connected by the pivot joint, gentle traction is made. The author has found that one of the blades used as a lever is more simple and efficient than the use of the two. A convenient form of instrument is made, having Lister's hook at the one end and Guye's curved arrangement at the other.

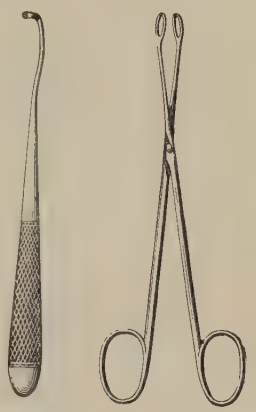

Fig. 142. Fig. 143.

Fig. 142.—Lister's instrument for removing foreign bodies from the ear.

Fig. 143.—Forceps of Dr. Guye for removing foreign bodies from the ear.

If there is a gap between the foreign body and the wall of the canal, such an instrument should be insinuated through this space and used as a lever to urge the body outwards. If there is no such gap, the foreign body being firmly impacted in the canal, the careful use of such a fine lever instrument will frequently enable us to expel the foreign body, or at least to displace it so that the use of the syringe and warm water may be more effective. All such instruments should be made as fine and small as possible, compatible with sufficient strength. In employing them it should be remembered that the upper part of the tympanic membrane is much *nearer* the outer orifice of the ear than the lower part (Fig. 148), and that when the foreign body is deeply seated the instrument should be introduced, if possible, antero-inferiorly.

A wire loop, such as Wilde's snare, is a safe method of attempting to remove a foreign body. If we are able in this way to encircle the object we may succeed in bringing it away, or we may be able to so change its position that its removal by the syringe, or by the lever instrument, is rendered easy or possible. The wire loop is of especial value when the foreign body has passed through a perforation in the tympanic membrane into the tympanic cavity.

We may also assist the expulsion of an object from the tympanum by the air douche, or by fluid injections through the Eustachian tube, or by suction with Siegle's speculum fitted air-tight into the external auditory canal.

If we have to deal with a pea or bean, which has undergone swelling by absorption of fluid, and has consequently become tightly impacted in the deep part of the canal of the ear, it may be necessary to break it down with a fine bent hook and remove it piecemeal or with the syringe. Voltolini recommends the galvanic cautery in certain cases, such as that of a tightly impacted bean, which may in this way be diminished in bulk by the partial destruction of its substance.

A suggestion of Lowenberg also deserves mention. He proposes that, after the object has been thoroughly dried, a fine brush which has been dipped into a solution of glue should be applied to the foreign body; after waiting for thorough drying and adhesion, the brush is to be withdrawn, when, if successful, the foreign body will be found glued to it.

If the object be long and pointed, and lying across the canal, with the points piercing its walls, as may happen with a needle or a piece of necrosed bone, it may require to be broken with forceps, and the pieces afterwards extracted separately.

Cutting Operations for the Removal of a Foreign Body. It only remains for us to consider certain cutting operations, which are recommended in cases where we are unable to achieve our object by the methods referred to, and where the symptoms produced by the foreign body are of such an urgent and serious character as to make its immediate removal from the ear imperative. In most of such cases the body has found its way into the deep parts of the canal or into the tympanum; and, by making an incision behind the auricle, and separating the cartilaginous from the osseous part, we may gain more complete access to the foreign body. In a case in which a facetted glass button was fixed in the tympanic cavity, the author exposed the osseous canal in this way (see p. 183), and, by means of an instrument similar to a blade of Guye's forceps, but made especially strong, the foreign body was safely extracted. It might be necessary in certain cases to remove a portion of the posterior wall of the osseous meatus, or even to open the antrum.

Insects, Larvæ, etc., in the Ear. Various insects, as fleas, bugs, flies, etc., sometimes find their way into the ear. Country folk, sportsmen, and field workers are more likely than town-people to be tormented by insects crawling into the ear.

The subjective symptoms set up depend upon the kind of insect which has got admission. There may be only the sensation of a moving body in the ear. But on the other hand, it is said that the presence of a flea may set up loud and most disagreeable noises, and even severe pain, by its leaping upon the tympanic membrane and the walls of the external auditory canal. A bug may excite very great pain by fastening upon and sucking some part of the canal or the tympanic membrane. The ear-wig (*forficula auricularia*) is an object of

great dread to many persons, owing to the belief that, if it gets into the ear, it will make its way to the brain, and produce some dreadful result. While it is true that this creature sometimes runs into the canal of the ear, any such hole having an attraction for it, there is no evidence that it has, on any occasion, produced dangerous effects.

The fly (*muscida sarcophaga*), attracted by the odour of the pus in neglected chronic purulent disease of the ear, sometimes deposits its eggs in the entrance to the ear, causing the development of larvæ or maggots. These may be found in great numbers, chiefly at the inner end of the canal and in the tympanum, appearing as white worm-like creatures, moving about. They are furnished with hook-like apparatus, with which they fasten upon and penetrate the tissue, exciting in this way the most intense pain. Sometimes, however, no pain attends their presence in the ear.

Treatment. It is easy to kill or expel insects which have found their way into the ear, by pouring water or oil into the ear and allowing it to remain for ten minutes. If these are not at hand, the smoke of tobacco from a cigar or pipe, blown into the canal, will quickly compel the insect to find its way into the open air. The expulsion of larvæ is to be effected by a more difficult process. Syringing with warm water will neither kill nor expel them. We must first apply some substance to the interior of the ear, which will cause their death. Rectified spirit, or the vapour of chloroform, is usually very effective. After they have been killed, they may require to be removed individually with forceps, as even after their death they so adhere to the walls of the canal, that simple syringing will not suffice to bring them away.

It is possible in applying leeches to the neighbourhood that one of them may escape into the ear. If such an accident should occur, a solution of common salt must at once be poured into the canal, after which the leech may be syringed out, or removed with forceps.

CHAPTER VIII.

THE TYMPANIC MEMBRANE.

ANATOMICAL AND PHYSIOLOGICAL DESCRIPTION.

Position—Attachment—Shape. The tympanic membrane, *membrana tympani*, or drum head (not the "drum") (Fig. 144), is a thin but strong inelastic membrane, which is stretched across the inner end of the external auditory canal and forms in great part the outer wall of the cavity of the tympanum. It is not tightly stretched, and is capable of a considerable extent of movement when the air in the external auditory canal is alternately condensed and rarefied. It is fastened to a groove in the annulus tympanicus (Fig. 133), the *sulcus tympanicus*, by means of a periosteal extension which constitutes the middle layer. This sulcus is, however, defective above, corresponding with the defect in the annulus tympanicus—the *Rivinian segment*. That part of the membrane filling up the Rivinian segment is thinner and looser than the rest, and is termed the *membrana flaccida*, or Shrapnell's membrane, forming the outer wall of a space—Prussak's space—in the tympanic cavity. It is not fixed to the bone, but simply connected to the skin of the canal of the ear. The loose attachment, as well as the absence of the fibrous layer, renders this part of the membrane more flaccid than the rest. The shape of the tympanic membrane varies in different persons, but is usually somewhat oval. Its longest diameter is from above downwards, and measures from 9 to 10 millimetres or about $\frac{2}{5}$ths of an inch, while its horizontal diameter is usually one millimetre less.

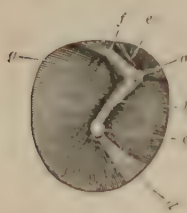

FIG. 144.—Outer aspect of right tympanic membrane—double the natural size; *a*, short process, *b*, middle of manubrium; *c*, umbo; *d*, cone of light; *e*, membrana flaccida; *f*, posterior fold; *g*, long process of incus shining through the membrane.

Obliquity and Curvature. It is not placed upright, but is so sloped as to form an angle of about 140 degrees with the upper and back wall of the canal, and one of 45 degrees with the lower and front wall. On account of this oblique position the upper and back part of the membrane is nearer to the external orifice of the ear than the lower and front part, a fact which should be borne in mind when operating upon the membrane or removing a foreign body from the ear.

It is also curved in such a way that its outer surface presents a general concavity. This is caused mainly by the inclination of the manubrium or handle of the malleus, and the deepest part is at the lower end or umbo of

that bone. Although there is this general concavity outwards, the membrane at several parts presents small bulgings towards the outside. These are in the situation of the cone of light, the short process of the malleus, and the anterior and posterior folds to be described presently.

Colour and Polish. The general colour of the membrane as seen from without during life is usually a pearl grey. In childhood it has a darker grey colour, while in old age it is whiter and more opaque. Immediately behind the umbo the membrane is whiter on account of its nearness to the whitish inner wall of the tympanum. The upper and back part has also generally a whiter appearance, which is due to the chorda tympani nerve and the posterior pouch of the membrane shining through.

The outer surface has, during life, a bright polished appearance, due to the reflection of light from the fine layer of epidermis. At the antero-inferior part the lustre is especially bright, and from its triangular form this is named the triangular light or the *cone of light*, the apex of this bright reflex being at the umbo and the base at the antero-inferior periphery of the membrane. The cone of light varies, even in healthy membranes, in length, breadth, and distinctness. In certain morbid conditions, especially after inflammation chiefly affecting the cutaneous or outer layer, the general polish as well as the cone of light may be dimmed or completely absent. For the description of the appearance of the membrane when seen through the external auditory canal, see p. 10.

Layers of the Tympanic Membrane. The tympanic membrane, with the exception of that part called the membrana flaccida, consists of three layers: (1) A cutaneous or outer; (2) a fibrous or middle; (3) a mucous or inner. The cutaneous layer can be easily separated from the middle layer, which, however, is intimately and inseparably united with the mucous layer.

The *external* or cutaneous layer is a very fine transparent prolongation of the lining of the external auditory canal. It is destitute of hair or the glandular elements of skin, and the cutis, which is very rich in blood-vessels and nerves, is covered by several strata of pavement epithelium. At the upper part, where this layer is thickest, the chief vessels and nerves pass down from the cutaneous lining of the roof of the canal, along the posterior edge of the manubrium to the umbo, from which the vessels radiate in small branches to the periphery, where they anastomose with smaller vessels from the other walls of the canal. These vessels, especially those passing down the membrane from the upper wall of the canal, become injected under various conditions apart from actual inflammation. After syringing the ear, after prolonged examination with the speculum, during the performance of Valsalva's method of inflation, or after suction by Siegle's speculum, they are apt to be injected. As a consequence of inflammation of the membrane the cutaneous layer may become thickened and opaque.

The *middle* layer, frequently termed the *membrana propria*, is the strongest layer of the membrane. It is composed of two sets of fibres, the outer or radiating and the inner or circular. The radiating fibres forming the lower part of the membrane are attached to the umbo, while the others are fixed to the anterior edge of the manubrium. The circular fibres are thickest in that zone of the membrane, which is intermediate between the centre and the circumference. The manubrium is fixed between the radiating and the circular fibres, and the peculiar arrangement of the fibres contributes to the strength of the membrane.

The *inner* or mucous layer is a continuation of the mucous lining of the tympanum. It is extremely thin and delicate, but in chronic catarrh of the middle ear it often becomes very much thickened. Its vessels anastomose with those of the cutaneous layer at the periphery of the membrane. It is much less endowed with nerves than the cutaneous layer. The so-called pouches of the membrane found on its inner aspect will be afterwards referred to under the description of the anatomy of the tympanic cavity.

The vascular and nervous supply to the tympanic membrane will be given in the appendix.

Function of the Tympanic Membrane. The tympanic membrane serves several purposes. It protects the middle ear from the effects of injurious atmospheric and other external influences. It supports the outer end of the bridge of bones, which spans the cavity of the tympanum. It is endowed with great capacity for vibrating in response to waves of sound transmitted to it by the column of air in the external auditory canal, and communicates these vibrations to the ossicles. Helmholtz showed experimentally that a curved membrane has much greater capacity for resonance than a flat membrane; but, on the other hand, Fick has demonstrated that the obliquity of a membrane weakens the effects of sonorous waves falling upon it. Vibrations corresponding to tones of all varieties of pitch and intensity are received at the one instant by this membrane and transmitted along the chain of bones. The non-elastic character of the membrane is supposed to prevent the tendency to after-vibrations; and it has been asserted that the radiating fibres are comparable to a system of stretched strings fixed at the one end and at the other attached to a movable cross-bar. It is interesting to note that there may be *fairly good hearing* when the membrane is perforated or even destroyed.

DISEASES OF THE TYMPANIC MEMBRANE.

As we might expect from its situation as a partition separating the external auditory canal without from the cavity of the tympanum within, the tympanic membrane generally shares in the diseases of these neighbouring parts. Primary disease of the membrane is met with, although it is generally impossible to say whether the disease is a primary one of the membrane, or whether it is secondary to a process which has had its origin in the tympanum or the external auditory canal. *Acute and chronic inflammations of the tympanic membrane* (*acute and chronic myringitis*) are described by authors. But, as these conditions rarely exist alone as primary conditions, and can almost never be distinguished as such, it seems to the author that to describe them would be more confusing than profitable. In practice we find that, with few exceptions, inflammation of the membrane is really part of an inflammation of the cavity of the tympanum of which it is the outer wall, and its description as well as that of the secondary changes which are found, such as perforation, retraction, calcareous deposits, etc., will be included in the Diseases of the Middle Ear.

INJURIES OF THE TYMPANIC MEMBRANE.

A traumatic lesion of the membrane may be the result of force applied directly to the tissue of the membrane, or indirectly through the intervention of the bones of the head or of the air in the canal of the ear.

Injuries Acting Directly. Of the injuries acting directly on the membrane the most frequent are caused by objects such as a knitting needle, hair pin, tooth-pick, straw, or small twig, being forced into the canal of the ear and through the membrane. While, for example, a woman is engaged in knitting, she applies the point of the needle to the external meatus to relieve a feeling of itchiness, and the needle, from some accidental cause, such as a push from some one passing, is driven into the ear and through the tympanic membrane. Such an accident is attended by a loud detonation and by very acute pain in the ear, with subjective sounds, while the person may become faint or giddy. There is usually some escape of blood from the ear, and on examining the membrane we find the seat of the penetrating wound covered with blood. When we are able to get a complete view of the parts, it is generally found that the wound is in front of the manubrium, and that around the aperture the membrane has a more or less dark red colour from extravasated blood. Cases are recorded of fracture of the manubrium resulting from such an injury. The membrane may also be wounded or even perforated by efforts to extract foreign bodies from the ear, by the improper use of the probe, by the point of a syringe with a long nozzle when clumsily used, by severe syringing, and by the long-continued pressure on the membrane of a foreign body or even of hard cerumen. Dangerous injury to the membrane may likewise be caused by boiling water, molten lead, or caustic substances finding admission into the ear. Perforating wounds of the tympanic membrane often heal quickly by first intention, but they may be followed by inflammation and suppuration of the middle ear.

Indirect Violence. Rupture of the membrane, due to indirect violence, may be caused—(*a*) by sudden and great condensation of the air in the external auditory canal or in the middle ear; (*b*) by concussion or fracture of the bones of the head. Both of these causes may act simultaneously, as in the case of a severe blow on the side of the head. In all cases the membrane is more likely to give way if it be already in a morbid condition, especially if atrophied, or if adhesions have formed with other parts, or if there be obstruction of the Eustachian tube, preventing the force expending itself in that direction.

Rupture of the membrane from sudden condensation of the air in the external auditory canal may arise from the report of artillery in the vicinity of the ear. A diver, striking the surface of the water with the side of the head, may have his tympanic membrane ruptured by the sudden condensation of the air in the canal of the ear. *Boxing the ears* is a not infrequent cause of rupture of the membrane. Dr. Chimani, of Vienna, found that of 54 cases of rupture of the tympanic membrane coming under his notice, 38 were due to this cause, and of these 36 were, as we might have expected, on the left side. A lady came under the observation of the author whose tympanic membrane was ruptured by the impact of a tennis ball upon the tragus.

Sudden condensation of the air in the naso-pharyngeal cavity, propagated to the air in the tympanum, may also rupture the membrane, particularly if the latter be weakened by disease. In this way the membrane has been ruptured in severe paroxysms of coughing, especially in whooping cough, in inflation by Politzer's method or through the Eustachian catheter, and, according to some authorities, in death by hanging.

At the moment of rupture of the tympanic membrane the patient usually experiences a loud crack in the ear, followed immediately by severe pain, by subjective sounds in the ear, by deafness, and sometimes by giddiness.

Appearance of the Tympanic Membrane after Injury. There may be considerable effusion of blood, not only into the external auditory canal, but also into the middle ear, and, through the Eustachian tube, into the nose and throat. The blood may for some days prevent a full or accurate examination of the condition of the parts. When a perforation of the membrane has a traumatic origin, it is found that by Valsalva's method air is forced through the perforation with a very distinct blowing sound, heard by bystanders, the inflation being much more easily and completely effected than in perforations from disease. The tear in the membrane is most frequently found behind the manubrium, or at the antero-inferior quadrant. The edges of the tear are not, as a rule, approximated, for the opening generally gapes and is oval or elliptical in form. Sometimes there is a flap inclining outwards or inwards. We may find ecchymosis in the neighbourhood of the rupture, and injected vessels along the manubrium. Inflammation and suppuration in the middle ear do not so often follow rupture of the membrane from force acting indirectly as in the case of direct wounds of the membrane. Within a week or two the opening heals, unless it has been injudiciously treated by irritating applications. If inflammation and suppuration do ensue, the parts generally recover in a few weeks, although occasionally the

disease takes a chronic course. If the injury be limited to rupture of the membrane, the function of the organ is, as a rule, completely regained. Sometimes the subjective sounds in the ear continue for a long time, and more rarely they remain a permanent annoyance.

Injury of the Deeper Parts. In addition to the rupture of the membrane, however, the nervous structures of the labyrinth may be injured by the concussion of the air or of the bones of the head. In such cases the deafness is greater, and the subjective sounds are more distressing, while both are likely to remain permanently. If the membrane be not ruptured, the injury to the labyrinth may be even still greater, as the force, not being spent in tearing the tissue of the membrane, is exerted upon the chain of bones, which may be driven violently in upon the fluid of the labyrinth, and so injure the terminations of the auditory nerve.

The tuning-fork, applied to the bones of the head, is very useful in giving us information as to the presence or absence of injury to the labyrinth. If the vibrating fork, when in contact with the nasal bones or middle line of the head, is heard *better* on the injured side, the great likelihood is that no serious mischief has happened to the nerve structures in the labyrinth.

Medico-legal Bearings. Rupture of the membrane, due to blows on the ear, may give rise to an action at law for damages. In the event of a legal inquiry the medical man should have the following points in view: (1) After the first few days it is impossible to determine with certainty whether a perforation of the membrane has had a traumatic origin, or has been the result of a pathological process. (2) Several months must elapse after the injury, before we are able to say if permanent mischief to the structure and function of the organ remains behind. (3) It is very difficult to say whether the deafness or the subjective sounds, complained of after an injury, may not be due to previous chronic disease in the middle ear, a condition which, in one ear or in both, affects a very large number of people. (4) If inflammation and suppuration follow the injury, it is within the range of possibility that very serious consequences, even death, may ensue. (5) If there be evidence of labyrinthine mischief having resulted from the injury, deafness and serious noises in the ear may continue during the whole of the patient's life.

Relation to Basal Fracture of the Skull. As is well known, fracture of the base of the skull is commonly attended by rupture of the tympanic membrane. In this case the tear is usually a continuation of a fissure made in the roof of the external auditory canal or in the roof of the tympanum. Usually copious bleeding takes place, partly from the vessels of the membrane and partly

from the osseous tissue. The escape of blood, however copious, from the external auditory canal or nose, after an injury to the head, does not necessarily mean that there is a fracture of the base of the skull. A considerable quantity of blood may escape from the ear and nose if the tympanic membrane be simply ruptured, or if there be tearing of the soft parts of the tympanic cavity and of the skin of the external auditory canal, without fracture of the osseous roof of the ear. We have already spoken of fracture of the tympanic plate of the external auditory canal being occasionally the source of bleeding from the ear (see p. 160).

The escape in considerable quantity of serous-looking fluid, which continues flowing for some time, is a much more serious indication of fracture of the base of the skull than the escape of blood. This symptom, after an injury to the head, generally means that there is fracture along the upper surface of the petrous part of the temporal bone, through the roof of the tympanum and the osseous part of the external auditory canal, with rupture of the tympanic membrane, tearing of the meninges, and escape of the cerebro-spinal fluid. The escape from the ear, a day or two after the injury, of a smaller quantity of serous-looking fluid, perhaps mixed with blood, is not however a certain indication of a fracture. This fluid may be due to a catarrh of the middle ear, set up by the injury, with fluid exudation escaping outwards through the fissure in the membrane. A basilar fracture of the skull does not necessarily involve a fatal termination; and, if the patient live, a purulent disease of the middle ear is likely to follow.

Treatment of Injuries of the Tympanic Membrane. When the membrane has been torn or ruptured, meddlesome treatment should be avoided. Cotton wool should be worn in the ear to protect the exposed tympanum from injurious atmospheric influences. Syringing with water or pouring into the ear various kinds of fluids is more likely to excite purulent inflammation of the middle ear than to expedite healing. If inflammation and suppuration ensue, these must be treated in the manner to be described afterwards.

All persons should be warned against the application of sharp-pointed instruments to the external meatus for the relief of itchiness. Besides the danger of injuring the membrane, the practice is injurious to the canal of the ear. Syringing the ear should be done with care, and syringes with very long thin nozzles should not be used. When the membrane is softened by acute inflammation, the patient is to refrain from strong expiratory efforts. The importance of great caution in the removal of foreign bodies from the ear has already

been fully referred to. Before taking a "header," the diver should plug the ears with cotton wool, and he should take care not to strike the surface of the water with the side of the head. The same precaution of stopping the ears with cotton wool should be adopted by artillerymen or persons who are exposed to loud and sudden sounds. Parents and teachers should be warned against inflicting chastisement by boxing the ears.

CHAPTER IX.

ANATOMICAL AND PHYSIOLOGICAL INTRODUCTION TO THE DISEASES OF THE MIDDLE EAR.

Under the term Middle Ear (Fig. 145) are comprised: (1) A passage—the *Eustachian tube*; (2) a narrow cavity—the *Tympanum*; (3) a cavity of considerable size above and behind—the *Antrum mastoideum*; (4) a large number of small spaces chiefly below and external to these—the *Mastoid cells*. These are in communication with one another, and, by the Eustachian tube, with the

Fig. 145.—Section through the whole extent of middle ear. A, Antrum mastoideum; B, mastoid cells; C, inner surface of tympanic membrane, at lower end of manubrium; D, head of malleus; E, body of incus; O, fossa for jugular bulb; H, pyramidal partition of bone separating the cavity of the tympanum from the antrum mastoideum; below the letter H, a portion of the canal for the facial nerve is shown; I, dura mater; K, chorda tympani nerve; L, tympanic mouth of Eustachian tube; M, isthmus of the Eustachian tube; N and P, cartilaginous walls of Eustachian tube; O, pharyngeal mouth of Eustachian tube.

naso-pharynx, while they are shut off from the external auditory canal by the tympanic membrane. They are mostly filled with air, and their walls, in great part formed of bone, are lined by mucous membrane, which is simply a continuation of the mucous membrane of the pharynx. In four situations the walls are composed of soft and more or less yielding tissue, namely, (1) the membrano-cartilaginous part of the Eustachian tube; (2) the tympanic membrane; (3) the membrane closing the fenestra rotunda; (4) the annular band of the fenestra ovalis.

As the middle ear is in reality an offshoot from the naso-pharyngeal cavity, we shall begin its description with the Eustachian tube.

THE EUSTACHIAN TUBE.

The pharyngeal mouth of the Eustachian tube (Fig. 146) is found on the outer wall of the naso-pharyngeal cavity (Fig. 14), just behind the posterior end of the inferior spongy bone. It is an opening of considerable size, measuring a third of an inch in the vertical direction, and a fifth of an inch in the horizontal direction. The upper and back part of the circumference of this opening presents a thick rounded bulging formed by the projection of the end of the median cartilage—the Eustachian prominence. This bulging is an excellent guide to the introduction of the Eustachian catheter.

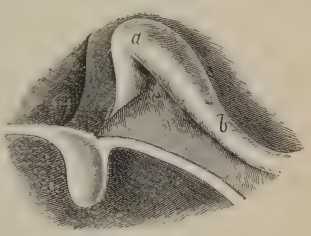

FIG. 146.—View of the left Eustachian orifice. *a*, Eustachian prominence; *b*, salpingo-pharyngeal fold; *c*, posterior tubal sulcus (Cresswell Baber).

From this opening the Eustachian tube passes outwards, upwards, and backwards, forming an angle of 135 degrees with the external auditory canal, till, at a distance of an inch and a half from the pharynx, it passes into the cavity of the tympanum. The walls of the third of the tube nearest the tympanum are formed of bone continuous with the upper

FIG. 147.—Cross section of lower third of membrano-cartilaginous part of Eustachian tube—right ear (Rüdinger). *a*, Median cartilage; *b* and *f*, folds of mucous membrane; *c*, fibro-cartilage at base of skull; *d*, the part of the canal enclosed by the hooked cartilage; *e*, end of the hook-shaped cartilage; *g*, the tensor palati muscle; *i*, attachment of the muscle to the cartilage; *k*, fatty tissue between the tensor palati and the membranous part of the tube; *l*, folds of mucous membrane in lower part of lumen of tube; *m*, levator palati muscle; *o*, isolated piece of cartilage lying below the lower end of the median cartilage

part of the tympanic cavity. The tensor tympani muscle lies in an osseous canal above, and parallel to, this part of the Eustachian tube.

Membrano-Cartilaginous Part of the Eustachian Tube. The other two-thirds of the tube are formed partly of cartilaginous and partly of membranous tissue. The point of junction between this and the osseous portion is the narrowest part, and is hence termed the *isthmus*, which measures three millimetres in height and half a millimetre in width. The membrano-cartilaginous part, which measures an inch in length, is not a permanently open tube, such as the external auditory canal. At its pharyngeal opening, and at a point near to its junction with the osseous part, it is permanently open; but, in the intervening part, the membranous wall lies against the cartilaginous, the mucous surfaces being in contact with one another, forming an S-shaped slit. This part, indeed, forms a kind of valve, which, by opening and shutting, regulates the supply of air to the rest of the middle ear. A transverse section of the membrano-cartilaginous part of the tube shows a peculiar arrangement (Fig. 147). The inner and upper part of the circumference is composed of cartilage, which is of considerable thickness, and is usually described as consisting of two parts, although there is no natural division between them—(1) a triangularly shaped plate of cartilage, called the median cartilage, which, near the osseous part of the tube, is attached to the fibro-cartilaginous tissue at the base of the skull, forms the inner wall of the tube; (2) the smaller portion or hook-shaped cartilage, which bends round from the upper part of the median cartilage in a direction downwards and then inwards, like a bent hook. The circumference of the tube is completed in the outer and lower parts by membranous tissue. This extends from the lower aspect of the hook-shaped cartilage to the inferior end of the median cartilage. The fibres of the tensor palati muscle are attached to the whole length of the membranous part of the tube and to the lower part of the hook-shaped cartilage, the fibres of the muscle having a direction almost at right angles to the walls of the tube. The levator palati muscle lies under the floor of the tube, with which its fibres are parallel.

THE TYMPANIC CAVITY.

From the outer or upper end of the Eustachian tube opens the most important part of the middle ear—the tympanic cavity, tympanum, or "drum of the ear." This is a narrow space (Fig. 148 B) interposed between the tympanic membrane and the wall of the labyrinth.

FIG. 148.—Vertical section of tympanic cavity. E, Roof of tympanic cavity; F, head of the malleus; G, foot-piece of stapes; H, floor of tympanic cavity; I, body of incus; K, Fallopian canal; L, tympanic membrane; M, short process of malleus.

Spanning this narrow space there is a bridge formed of three bones—the malleus, incus, and stapes (Fig. 149), constituting an osseous connection between the tympanic membrane and the labyrinth.

The narrowest part of the cavity measures two millimetres or one-twelfth of an inch, and occurs between the tympanic membrane, at the lower end of the manubrium, and the inner wall. The widest part, measuring fifteen millimetres, extends from the opening of the Eustachian tube to the opening into the antrum exactly opposite. From the roof to the floor, on a line with the manubrium, the cavity measures twelve millimetres.

We shall describe the walls of the tympanic cavity in the following order:

(1) Outer wall or tympanic membrane; (2) inner or labyrinthine wall; (3) roof; (4) floor.

FIG. 149.—I. Malleus; II. Incus; III. Stapes. (From Rüdinger.)

Inner Aspect of the Tympanic Membrane (Fig. 150). The handle of the malleus is seen fixed into the membrane, as already described, while the head projects upwards and inwards, till its upper surface is close to the roof of the tympanum. The posterior surface of the head of the malleus is articulated to the head of the incus, whose long process extends downwards, behind and parallel with the manubrium at a distance of two millimetres from the postero-superior quadrant of the membrane, but it does not extend so far down as the lower end of the manubrium. The short process of the incus passes backwards and slightly downwards to rest with its tip on the floor of the opening into the antrum mastoideum.

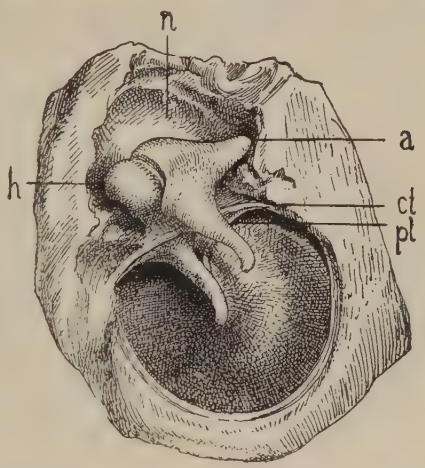

FIG. 150.—Inner surface of the right tympanic membrane, with the malleus and incus, enlarged 3½ times (Politzer). *n*, Malleo-incudal niche at the outer wall of the attic of the tympanum; *h*, head of the malleus; *a*, incus; *pl*, von Tröltsch's pouch; *ct*, chorda tympani.

The Attic. It is to be noted that the upper half of the malleus and the body and short process of the incus are higher than the tympanic membrane, in what is called the upper tympanic cavity or *attic*. This cavity measures about six millimetres in height, its outer wall being the inner end of the roof of the external meatus. The head of the malleus and the body of the incus are here articulated together in such a way as to form an osseous partition, incompletely dividing the space into an outer and an inner compartment, the inner being the wider of the two. The outer is termed the outer attic (Fig. 151), which is divided into a lower—Prussak's space—having the membrana flaccida as its outer wall and limited above by the external ligament of the malleus;

and an upper space limited above by the superior ligament of the malleus, and subdivided into a number of spaces by folds of the mucous membrane. Suppurations having their seat in the outer attic are as a rule particularly intractable and attended by perforation of the membrana flaccida.

FIG. 151.—Section through the tympanic membrane, malleus, upper and outer tympanic wall of a decalcified preparation. *ls*, Ligamentum mallei externum; *s*, membrana Shrapnelli; *o*, Prussak's space; *r*, system of cavities between the malleus and incus, and the external tympanic wall; *t*, tendon of the tensor tympani muscle. (After a preparation in Politzer's collection.)

The Pouches of the Tympanic Membrane. On removing the incus a fold of fibrous tissue is seen, extending between the upper part of the manubrium and the posterior wall of the tympanum near to the sulcus tympanicus. This forms the inner wall and the corresponding part of the tympanic membrane forms the outer wall of a space, open below, and named by von Tröltsch the posterior pouch of the membrane. There is a much smaller space in front of the manubrium—the anterior pouch. The chorda tympani nerve, coming from the facial nerve in the Fallopian canal, is seen forming the lower edge of the inner leaf of the posterior pouch; it then comes in close contact with the inner surface of the neck of the malleus, and, after taking part in the formation of the anterior pouch, it finally emerges from the tympanum by the Glaserian fissure or petro-tympanic suture on its way to the tongue.

The Inner Wall of the Tympanum (Fig. 152). Here are found the two openings in the bone closed by membranes, which separate the tympanum from the watery fluid of the labyrinth. These openings are the *fenestra ovalis* or opening into the vestibule, and the *fenestra rotunda* or opening into the cochlea. The fenestra ovalis is in the upper and back part of the inner wall of the tympanum, at the bottom of a recess or niche, the *pelvis ovalis*. This recess is seen to accommodate the stapes, the footpiece of which is attached to the membrane closing the fenestra ovalis; while its head, in the natural condition, articulates with the lower end of the long process of the incus. The slender crura of the stapes are separated by only a very small interval from the walls of the pelvis ovalis. The base of the stapes does not completely fill up the fenestra ovalis, there being a small space between the circumference of the footpiece of the stapes and the edge of the opening. This space is filled up by an annular band of fibrous tissue, lined on its inner surface by the periosteum of the vestibule, and on its outer surface by the mucous membrane of the tympanum. The fenestra rotunda, closed by the *membrana tympani secundaria*, is also situated at the bottom of a recess in the bone. This recess is lower down than that leading to the fenestra ovalis,

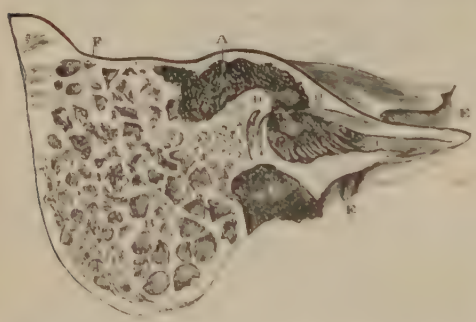

FIG. 152.—View of inner half of osseous part of middle ear. A, Antrum mastoideum; B, mastoid cells; C, promontory on inner wall of tympanum—above is seen the stapes in its recess; D, partition between cavity of tympanum and antrum—below is part of the canal for the facial nerve, and in front of this canal the stapedius muscle; E, the carotid canal; F, the dura mater; G, the fossa for the jugular bulb; H, the belly of the tensor tympani muscle; I, inner wall of the osseous part of the Eustachian tube.

at the postero-inferior part of the inner wall of the tympanum. It looks *backwards* and not outwards like the pelvis ovalis, and, owing to this peculiarity, the membrana tympani secundaria can never be seen from without even in complete destruction of the tympanic membrane. Only the anterior rounded edge of the opening leading to this recess is visible from the outside. Between, and in front of, the openings leading to these two fenestræ is the *promontory*, a smooth rounded prominence just opposite to the middle and anterior part of the tympanic membrane. It forms the outer wall of the first turn of the cochlea. In front of this the inner wall of the tympanum is thin and porous, and is continuous with the inner wall of the osseous part of the Eustachian tube. Behind and above the fenestra ovalis there is an elongated prominence constituting the upper wall of the pelvis ovalis. This is a part of the Fallopian canal—the osseous tube which contains the facial nerve. At the uppermost and hindermost part of the inner wall of the tympanum a smooth white surface is seen marking the position of the external or horizontal semicircular canal. At the upper part of the inner wall of the tympanum, at the junction of the inner wall with the roof, there is seen a part of the slender osseous canal (not usually complete) containing the *tensor tympani* muscle. This osseous canal extends above, and parallel with, the Eustachian tube, while posteriorly, just above and in front of the pelvis ovalis, it terminates in a process round which the tendon of the tensor tympani muscle turns outwards so as to cross, in the natural condition, the tympanic cavity, and be inserted into the manubrium just below the neck of the malleus. Behind and below the entrance to the fenestra ovalis there is a conical osseous eminence—the pyramid—containing a canal for the *stapedius* muscle, for, like the tensor tympani, it is enclosed in a bony canal. This is the smallest striated muscle in the body, and its tendon is inserted into the posterior part of the head of the stapes. Behind the canal containing the stapedius muscle lies a part of the Fallopian canal.

FIG. 153.—Vertical section through tympanum, antrum, and mastoid cells, which are partly pneumatic and partly diploetic. A, Antrum mastoideum; B, mastoid cells; C, inner surface of tympanic membrane; D and E, head of malleus and body of incus, forming the osseus partition dividing the upper tympanic space into two compartments—in the drawing the outer compartment is concealed by these two bones; F, chorda tympani nerve; G, fossa for jugular vein; H, pyramidal partition of bone separating the cavity of the tympanum from the antrum mastoideum. Below the letter H, a portion of the canal for the facial nerve is shown; I, dura mater.

The roof of the tympanum—*tegmen tympani*—consists of a layer of bone of very variable thickness and density, which forms part of the floor of the middle cranial fossa, and is lined on its upper surface by dura mater. The floor of the tympanum is also formed of a layer of bone of very variable thickness, and has a tesselated appearance, being thrown into many small depressions and ridges. It is at a somewhat lower level than the floor of the external auditory canal.

ANTRUM MASTOIDEUM AND MASTOID CELLS.

Antrum Mastoideum. A distinct opening in the upper part of the posterior wall of the tympanum, just opposite to the mouth of the Eustachian tube, leads into the *antrum mastoideum*, or horizontal part of the mastoid cells (Fig. 153). The upper tympanic space, to which we have already referred, passes directly backwards into this, and the tympanum and antrum mastoideum are roofed in by one and the same lamina of bone, separating both spaces from the dura mater lining the floor of the middle fossa of the skull. But, while they are continuous at the upper part, the lower two-thirds of these cavities are separated from each other by a thick pyramidal partition of bone, in consequence of which the floor of the antrum is at a much lower level than its opening of communication with the tympanum. This formation is very unfavourable to the escape of secretion collected in the antrum. The upper or narrow part of this partition is a rounded ledge, which forms the floor of the passage between the tympanum and the antrum, and on this ledge the short process of the incus rests. The antrum mastoideum is separated from the postero-superior wall of the inner end of the external auditory canal by only a thin layer of bone, which, in purulent diseases of the antrum, may be perforated by caries.

Mastoid Cells. The remaining cellular spaces in the mastoid process, sometimes termed the vertical cells, are of various sizes (Fig. 153), and are situated for the most part lower down, and more superficially, than the antrum. The largest of them and the greatest number are found in the mastoid part of the temporal bone, which presents great variety in size and length, but they occur also in various other parts of the temporal bone. They exist, for example, in the bone forming the roof and floor of the tympanum, in the roof of the osseous part of the external auditory canal, and even towards the apex of the petrous part of the temporal bone. They sometimes extend backwards as far as the occipital bone. These cellular spaces also present great varieties of size in different persons as well as in the nature of their contents. In less than half of the temporal bones examined the spaces are entirely *pneumatic* or air-filled, and they are usually larger in a bulky mastoid process; those cells which are near the antrum generally communicate with that cavity. In the majority of temporal bones the cells are partly pneumatic and partly *diploetic*, containing a fatty substance. The diploetic substance usually occupies the lower part of the mastoid process. The larger number may be diploetic, and in some cases the whole mastoid process, with the exception of the antrum, may be occupied by small diploetic spaces containing no air. The *sclerotic* mastoid is also met with; here there is dense ivory-looking bone with few or no cellular spaces. This condition

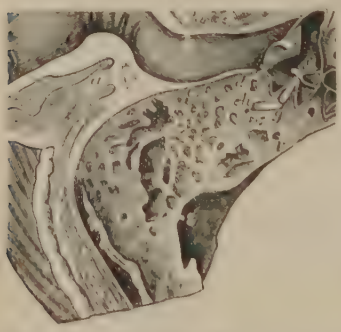

FIG. 154.—Horizontal section through the external auditory canal, tympanum, and mastoid cells, showing the relations of the latter to the two former (after Rüdinger). *a*, Posterior cartilaginous wall of external auditory canal; *b*, external auditory canal; *c*, anterior wall of mastoid cells, or posterior osseous wall of external auditory canal; *d*, tympanic membrane; *f*, cavity of tympanum close to stapes; *g*, stapedius muscle; *h*, a portion of facial nerve; *r*, section of a semicircular canal; *s*, inner wall of mastoid cells, over the groove for the lateral sinus; *u*, outer wall of mastoid cells.

is met with most frequently as a consequence of chronic purulent disease of the middle ear. In advanced years it is also frequently found. It is important to remember that the antrum is usually *smaller* and *more deeply situated* in the sclerotic mastoid. The antrum and mastoid cells are enclosed by a shell of compact bone, the cortical part (Fig. 154). That which bounds the cells internally is related above and mesially to the groove for the lateral sinus, while below, where it is sometimes very thin, it forms the outer wall of the digastric groove (Bezold). At the roof—*tegmen antri*—the cortical part is in contact with the dura mater, and in front it forms the posterior osseous wall of the external auditory canal. Externally it forms the convex surface, very variable in size and thickness, behind the auricle. As the result of purulent disease in the mastoid cells fistulous openings often form spontaneously on this external wall, which is also the situation where artificial perforation is most frequently performed for the relief of purulent collections in the mastoid cells.

PECULIARITIES OF THE MIDDLE EAR IN CHILDHOOD.

The middle ear presents in the young child some peculiarities worthy of attention. The *tympanic membrane* is (1) thicker and, in proportion to the

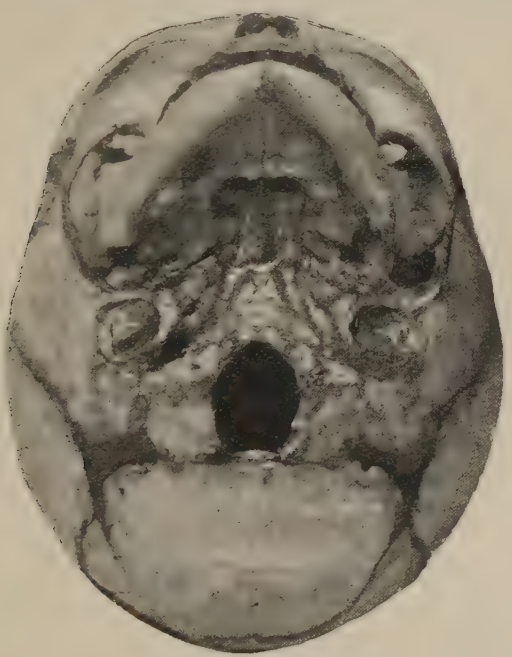

FIG. 155.—Base of skull of new-born infant, showing tympanic membranes almost on a level with the base of the skull.

size of the body, much larger than in the adult, indeed, shortly after birth, it has attained almost its complete size; (2) it is rounder in shape and darker in colour than in the adult; (3) its position is more *horizontal*. At the end of fœtal life it really forms part of the base of the skull (Fig. 155), and is almost

on a line with the roof of the external auditory canal. With the development of the lateral walls of the skull, the membrane gradually takes the position which it has in the adult. The *Eustachian tube* is shorter, wider, more horizontal, and less cartilaginous. On this account the tube is more easily inflated in childhood, while secretion passes more readily from the tympanum to the pharynx than in the adult. The projection at the upper and back part of the mouth of the tube is also much less marked, and the pharyngeal opening is not so open, being more like a slit. In early childhood the *mastoid cells*, with the exception of the antrum mastoideum, are very slightly developed (Fig. 156), the mastoid process being not only very small, but consisting simply of cancellated bone. During the first few years of life it gradually develops downwards and outwards, till it acquires the conical bulging form. The *antrum mastoideum* is, however, in childhood always well developed, and it occupies a more superficial position than in the adult. It is also higher up (being really in the squamous portion of the bone). There is also often in childhood a very distinct fissure in the roof of the tympanic cavity, the squamo-petrosal fissure. Through this fissure a process of dura mater, with vessels and nerves, passes down, and becomes continuous with the mucous membrane lining the tympanum. The tympanic cavity is occupied by a gelatinous tissue before birth, after which this tissue quickly degenerates and becomes absorbed, giving place to air.

FIG. 156.—Outer view of the temporal bone of a new-born infant (Left). *a*, Upper portion of the squama; *b*, its inferior portion, below is the linea temporalis passing backwards; *c*, annulus tympanicus; *d d*, suture between the squamous portion and the mastoid process, extending to the foramen stylo-mastoideum; *e*, foramen stylo-mastoideum; *f*, fenestra ovalis; *g*, fenestra rotunda. (Politzer.)

LINING MEMBRANE OF THE MIDDLE EAR.

The walls and contents of the middle ear are everywhere lined by mucous membrane. We saw that the cutaneous lining of the ear became gradually thinner from without inwards, until over the outer surface of the tympanic membrane it became so thin as to be transparent. So the mucous lining of the ear, comparatively thick at the pharyngeal mouth of the Eustachian tube, becomes gradually thinner as it passes up, until over the walls and contents of the tympanum and the interior of the antrum and pneumatic mastoid cells it is quite transparent. At the pharyngeal mouth of the tube the mucous membrane contains a large number of racemose glands, which are also found, but in less number, higher up. In the membranous part of the tube the mucous membrane is thrown into numerous folds. In the whole of the Eustachian tube and partly in the tympanum the membrane is provided with ciliated epithelium, the movements of the cilia being directed towards the pharynx. In the tympanum the extremely delicate mucous membrane covers the small bones, the tendons of the muscles, the fenestral structures and recesses—in short, the whole of the walls and contents of this cavity. Over the osseous walls and the small bones it is inseparably united to the periosteum, so that

we must look upon every inflammation of this lining as having the gravity of a periostitis.

The Diseases of the Middle Ear are simply various grades of catarrh or inflammation of the mucous membrane, and the pathological changes, found in the different parts of the middle ear, causing disturbance of the function of the organ, are generally due to the effects of these catarrhal processes. In the Eustachian tube, the swelling and exudation frequently obstruct the canal, while agglutinations and adhesions may take place, and hinder the proper separation of the walls during swallowing. So in the cavity of the tympanum the swelling or thickening of the mucous membrane may cause adhesions between the outer and inner walls. Again, exudation of mucus, serum, or pus may partially or completely fill the cavity of the tympanum and even the mastoid cells, often leading to other and permanent changes. It is found, however, that thickening, swelling, and hypersecretion of the mucous membrane covering the chain of bones, especially the stapes, and of that lining the walls of the two fenestral recesses and of the fenestral membranes themselves, are particularly injurious to the function of hearing. In this way the delicate movements of the bridge of bones, and more especially of the stapes, and the mobility of the structures closing the fenestræ, are seriously disturbed. The mucous membrane lining the mastoid cells, especially the antrum mastoideum, generally shares to a greater or less extent in the catarrhal or inflammatory states of that lining the tympanic cavity.

THE RELATIONS OF THE WALLS OF THE MIDDLE EAR TO NEIGHBOURING PARTS.

These are of very great importance in view of the effects which may result from purulent inflammation of the mucous membrane of the middle ear. The bony walls of the middle ear are at particular parts in direct contact with, or closely contiguous to, (1) the dura mater and brain; (2) large blood-vessels; (3) the facial nerve (Fig. 157).

Relation to the Dura Mater and Brain. The dura mater is separated from the mucous membrane of certain parts of the middle ear by thin bone. At one part this bony partition separates the tympanum, antrum, and mastoid cells from the dura mater lining the floor of the middle fossa of the skull, where rests the temporal lobe of the brain. At another part the bony partition separates the antrum and mastoid cells from the lateral and anterior part of the posterior fossa, where we find the concavity for the sigmoid sinus. These osseous partitions are never thick, and are frequently so thin as to be transparent. They are always perforated with apertures for connective tissue, vessels, and nerves, especially at the roof of the tympanum where there exists the squamo-petrosal suture. Again, in a considerable number of skulls, gaps caused by defective development are found in either or both of these partitions, so that at these gaps the dura mater and the mucous membrane of the middle ear are in direct contact. Through these two partitions inflammatory or purulent diseases of the middle ear may extend either by carious openings (Fig. 158) or by the blood-vessels, or by direct continuity of tissue, to the dura mater and brain.

But there is another pathway by which the inflammatory or purulent process may pass to the dura mater, namely, through the interior of the labyrinth. The cochlea may be invaded through the fenestra rotunda, or

through a carious aperture in the promontory. The vestibule may be broken into by ulcerative disease, extending through the structures closing the fenestra

FIG. 157.—Section through the right temporal bone, showing some of the relations of the cavities of the middle ear. 1, Below is the groove for the lateral sinus, and in front is the roof of the antrum; 2, mastoid foramen (with bristle introduced). A vein from the sigmoid sinus passes outwards through this foramen. 3, The vertical mastoid cells; 4, the antrum mastoideum; 5, styloid process; 6, the tympanic membrane close to its insertion in the sulcus tympanicus—the mucous layer extending somewhat beyond the sulcus; 7, the malleus; 8, the incus; 9, short process of the incus; 10, chorda tympani nerve; 11, the stapes with its foot-piece slightly turned up, to show the head and crura; 12, stapedius muscle; 13, facial nerve, giving off, 14, the branch to the stapedius. (From Rüdinger.)

ovalis. Caries of the extreme upper and back part of the inner wall of the tympanum may convey disease to the interior of the horizontal semicircular canal. The disease having reached the interior of the labyrinth is separated from the dura mater of the internal auditory canal only by the perforated lamella of bone, through which pass the fibres of the auditory nerve.

Instances are also recorded, in which the disease passed from the tympanum to the internal auditory canal by the Fallopian canal and sheath of the facial nerve.

Relation to Blood-vessels. One of the main arterial trunks and three venous channels are in close proximity to, and only separated by thin osseous walls from, the mucous membrane of the middle ear. The *internal carotid artery*, contained in the carotid canal, lies on the other side of the inner wall of the tympanum and osseous part of the Eustachian tube. The great intracranial venous trunk, the *sigmoid sinus*, is separated from the mastoid cells only by the inner wall or cortical covering of the latter. Scarcely less important

is the position of the *internal jugular vein* at its bulb exactly under the floor of the tympanic cavity, while of less, but yet of considerable importance, is the proximity of the *superior petrosal sinus*, which is situated upon

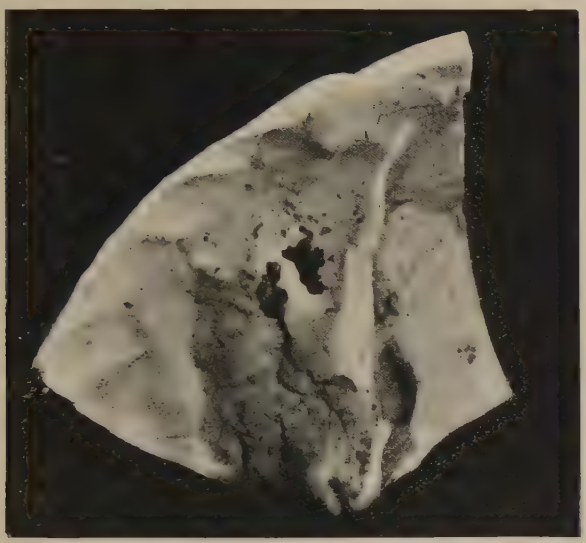

FIG. 158.—Upper and anterior surface of petrous portion of temporal bone, showing carious apertures in the roof of the middle ear, from patient who died from cerebral abscess.

the upper edge of the petrous part of the temporal bone near the roof of the middle ear. The osseous partitions separating these vessels from the middle ear have the same peculiarities as the osseous partitions in contact with the dura mater. They may be thin to transparency, they may have gaps, and they are perforated by openings for connective tissue, vessels, and nerves. In purulent diseases of the middle ear any one of these blood channels may be involved. From the internal carotid fatal hæmorrhage has ensued, due to caries of the osseous partition. In the venous channels, especially the *sigmoid sinus*, septic thrombosis with its consequences is not unfrequently caused by purulent diseases of the middle ear. The positions of the internal carotid artery and of the internal jugular vein with reference to the middle ear also explain the sense of throbbing and the venous murmurs experienced in the ear by some persons.

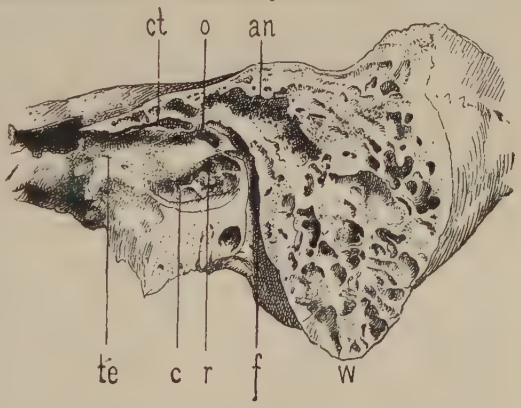

FIG. 159.—Sagittal section through the roof and floor of the tympanic cavity, showing the course of the facial nerve. *te*, Osseous Eust. tube; *ct*, canal for tensor tympani muscle; *c*, floor of tympanum; *o*, fenestra ovalis; *r*, fenestra rotunda; *an*, antrum; *f*, canal for facial nerve; *w*, mastoid process. (Politzer.)

Relation to the Facial Nerve. We have seen the close connection of the facial nerve with the inner wall of the tympanum and the mastoid cells (Fig. 159). The osseous partition separating the nerve from the mucous membrane of the middle ear is often extremely thin and sometimes defective, especially in its position above the fenestra ovalis. We meet with facial paralysis not only in purulent diseases, but also in simple congestions of the mucous membrane of the middle ear.

FUNCTIONS OF THE MIDDLE EAR.

The various parts of the middle ear either directly or indirectly conduct sonorous vibrations from the external auditory canal to the fluid of the labyrinth.

Function of the Tympanum. The tympanum is engaged directly in the conduction of sound, while the Eustachian tube and the mastoid cells are indirectly concerned in the due performance of this function. While the air in the tympanic cavity and the membrana tympani secundaria are to some extent the media by which the vibrations of the tympanic membrane are transmitted to the fluid of the labyrinth, there is no doubt that the chain of small bones—the malleus, the incus, and the stapes—with the membrane closing the fenestra ovalis, forms the chief conducting medium between the tympanic membrane and the fluid of the inner ear. The chain of bones forms a delicate lever apparatus, which is placed, by the vibrations of the tympanic membrane, in a state not only of molecular movement, but also of movement *en masse* inwards and outwards. These movements are much more extensive in the malleus than in the stapes. According to the experiments of Dr. Buck, of New York, the extent of movement is twice as great in the malleus as in the incus, and twice as great in the incus as in the stapes. The labyrinth is protected in this way against the effects of great concussions in the neighbourhood of the ear, or of undue inward pressure of the tympanic membrane. On the other hand, when the air in the middle ear is abnormally compressed, and the tympanic membrane thereby forced outwards, the excessive withdrawal of the stapes from the fenestra ovalis is hindered by the structure of the joint between the malleus and the incus. This is furnished with a "catch," which limits the movement outwards of the long process of the incus, and renders it much less than that of the malleus. The movements of the base of the stapes are very limited. According to Helmholtz, when the membrane is moved outwards and inwards by alternate condensation and rarefaction of the air in the external auditory canal, the movements or excursions of the stapes do not extend over more than an eighteenth to a fourteenth of a millimetre. In the movements excited by sonorous vibrations, the excursions of the stapes are extremely short; in very weak yet clearly perceptible tones they escape recognition even by a powerful microscope. The vibrations probably become intensified in passing from the comparatively large tympanic membrane to the much smaller membrane closing the fenestra ovalis.

Function of the Eustachian Tube. By the free passage of air through the Eustachian tube, the atmospheric pressure is always the same on both sides of the tympanic membrane. This ensures a proper degree of tension of the membrane and ossicular chain, which is essential to the healthy condition of the ear. Whenever there is a hindrance to the due passage of air through

the Eustachian tube, the tension is disturbed, because, the air in the tympanic cavity becoming more rarefied than the air on the outer surface of the tympanic membrane, the latter is pressed unduly inwards, and its tension as well as that of the whole chain of bones is increased. It has been pointed out that, in ordinary conditions, the greater part of the membrano-cartilaginous tube is closed. It opens, however, every time one performs the act of swallowing ; and it is found that air may pass from the naso-pharyngeal cavity to the tympanum at other times also. During ordinary breathing the tympanic membrane in some persons moves synchronously with inspiration and expiration, but probably in these cases the tube is unusually wide and open. In forced expiratory efforts, as coughing, singing, blowing the nose, etc., the air may pass through the Eustachian tube to the cavity of the tympanum. If the nasal passages are closed from any cause, these expiratory efforts have a greater effect in forcing air through the Eustachian tubes. The width and permeability of the Eustachian tubes undoubtedly vary much in different persons and even in the same person in different circumstances, such as the state of the weather, etc. Fluid secretion in the tympanic cavity may, in certain circumstances, escape through the Eustachian tube to the nasal passages, but the situation of the tympanic opening of the tube at the *upper* part of the tympanum is unfavourable to its function as an exit tube.

Function of the Mastoid Cells. Besides imparting lightness to the thick temporal bone, the air-filled mastoid cells act as resonance chambers to the tympanic vibrating structures and thus intensify the sound, while they also form a reservoir for supplying the tympanum with air, in partial or temporary obstruction of the Eustachian tube.

Functions of the Four Muscles of the Middle Ear. The *tensor palati* or *circumflexus palati* is the chief means of opening the Eustachian tube. From the direction and attachment of the fibres, already referred to, it is clear that when this muscle contracts, as it does during the act of swallowing, the outer or membranous wall, with the hook-shaped cartilage, is withdrawn from the inner wall. As this muscle seems to have no action on the soft palate, its action being confined to the Eustachian tube, von Tröltsch suggested that it be named the *abductor tubæ*. The tensor palati receives its nervous supply through the otic ganglion from the motor fibres of the fifth nerve (internal pterygoid branch).

The *levator palati* muscle has a much less important action on the tube, being chiefly a palate muscle. During contraction it forces the floor of the tube upwards and backwards, and in this way increases the transverse diameter of the tube. It is supplied by a branch from the pneumogastric nerve and also by one from Meckel's ganglion.

The *tensor tympani* muscle in contracting pulls the handle of the malleus inwards, and thus increases the tension of the tympanic membrane. The inward movement of the malleus is communicated to the long process of the incus, and the stapes is thus pressed in upon the labyrinth. The tendon of this muscle is apt to become abnormally and permanently shortened, when the tympanic membrane has continued for a length of time in an indrawn position, and the contracted tendon may resist any efforts made to restore the tympanic membrane and ossicular chain to their proper position and degree of tension. It receives its nervous supply from the same source as the tensor palati.

The *stapedius* muscle is understood to have an action antagonistic to that of the tensor tympani. It prevents the stapes from being unduly forced into the fenestra ovalis. It derives its nerve supply from the facial nerve in the Fallopian canal.

The function of these two muscles therefore is to regulate, in some degree, the tension of the tympanic membrane and ossicular chain, and thus to *preserve the due amount of pressure* of the stapes upon the fluid of the labyrinth.

Some writers describe another muscle—the *salpingo-pharyngeus*—as acting upon the tube. Good authorities, however, look upon this as merely a fascia. If muscular, it may be considered as contributing to the fixed position of the median cartilage.

The vascular and nervous supply of the middle ear is described in the Appendix.

CHAPTER X.

PURULENT OR PERFORATIVE INFLAMMATION OF THE MIDDLE EAR.

THIS is probably the most important of all the diseases of the ear, not only on account of its frequency, but also of its serious effects upon the ear as well as upon the surrounding structures, effects which often involve life itself. As to its frequency, statistics drawn up by various authorities agree in showing that from 30 to 35 per cent. of all ear diseases belong to this class; 5 per cent. belonging to the acute and the remainder to the chronic stage.

The early stage, especially if attended by painful symptoms, is usually termed *acute purulent or perforative inflammation of the middle ear* (*otitis media purulenta acuta*), *acute purulent ear catarrh* (von Tröltsch), *acute suppuration of the middle ear* (Roosa). If the affection has gone on for a few months, it is termed *chronic purulent inflammation of the middle ear* (*otitis media purulenta chronica*), *chronic purulent ear catarrh* (von Tröltsch), *chronic suppuration of the middle ear* (Roosa), *pyogenic otitis media*. Also it is frequently spoken of as *otorrhœa* from its most pronounced symptom, discharge from the ear.

In his description of purulent disease of the middle ear, however, the author has not followed the usual plan of separating the acute form from the chronic, but has regarded the former as simply the early stage. Both are therefore included in the common term of *purulent inflammation of the middle ear*, and this is described in three stages: (1) The stage before perforation; (2) the stage of purulent discharge; (3) the stage after the discharge has ceased—the non-secreting stage.

PATHOLOGY.

Acute Stage. In the early stage of the disease the mucous membrane of the middle ear, *especially of the tympanic cavity*, is in a state of congestive swelling and exudation. The exudation consists of serum, mucus, pus, or blood in varying proportions. In severe forms the inflammation and swelling become more intense, the deeper layers of the mucous membrane, corresponding to

periosteum, are involved, while the exudation becomes more purulent in character. There is in most cases a tendency to softening, ulceration, and destruction, while, with few exceptions, it is *attended by perforation of the tympanic membrane.* The disease is frequently confined to one ear, although both may be affected, especially in the exanthematous diseases. In cases which are not of very long duration the swelling is due to dilated vessels and interstitial serous or cellular infiltration, chiefly in the sub-epithelial tissue. As time goes on the epithelial lining usually becomes lost and the surface presents a red, soft, granular, or smooth appearance. From this surface granular or papillary excrescences or polypi may project as the results of hyperplastic growth.

In the Chronic Stage there is frequently new-formation of connective tissue elements, leading to dense thickenings, adhesions, or cicatrices. Calcification and atrophy not unfrequently take place both in the mucous lining of the middle ear and in the tympanic membrane. In a very advanced stage the mucous membrane may become pale or even white from atrophy. The morbid process may also lead, even in the acute stage, to *serious changes in the osseous walls and ossicula*, such as erosion or caries, necrosis and exfoliation, or thickening and hyperostosis. Some cases, especially in young children, associated with caries and enlarged cervical glands, are really tubercular (see p. 55). Caseous and cholesteatomatous masses are frequently found in the attic and antrum. In both the acute and chronic forms the adjoining parts of the ear, the external auditory canal on the one side, and the labyrinth on the other, generally participate more or less in the inflammatory process. In the labyrinth, while this participation may simply consist of transient hyperæmia, with perhaps serous exudation, there may, on the other hand, be destructive purulent formation (*panotitis*), **leading to total and permanent loss of hearing.**

Purulent inflammation of the middle ear is in a few exceptional cases unaccompanied by perforation of the membrane, owing probably to previous thickening of its layers. In such circumstances the purulent secretion escapes either through the Eustachian tube or by an opening in the cortical part of the mastoid cells behind the auricle, or in the osseous part of the external auditory canal. Purulent collections in the middle ear unattended by perforation of the membrane seem to be relatively common in new-born or very young infants (von Tröltsch).

CAUSES OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

The disease is met with at all ages, but frequently begins in childhood, originating in very many cases before the age of fifteen years.

Exciting Causes. The following are the most important exciting causes. (1) The exanthematous diseases—scarlet fever, measles, and smallpox. Scarlet fever complicated with nasal diphtheria probably gives rise to the most destructive and persistent type of the disease. (2) The extension of nasal and pharyngeal catarrh through the Eustachian tube to the tympanic cavity. (3) The action of cold through the external meatus, as in diving or immersing the head in water: exposure of the ear to cold wind especially with rain, sleet, or snow; or the trickling of water into it from ice applied

to the head. (4) Reflex action, as from cold feet, teething in infants, or dental disease. (5) Injuries, such as a blow on the ear, the presence of foreign bodies or *instrumental efforts* to remove them, caustic applications, traumatic rupture of the tympanic membrane, the propulsion of fluid by the nasal douche through the Eustachian tube into the tympanum. (6) General diseases (in addition to the exanthemata which have been already referred to). Epidemic influenza in which there seems to be a special tendency to mastoid inflammation, mumps, diphtheria, phthisis pulmonalis, typhoid fever, malarial diseases, diabetes, pneumonia, and bronchitis are all recognized causes. A form apt to be accompanied by effusion of blood into the tympanic cavity (*otitis media hæmorrhagica*) is sometimes associated with chronic Bright's disease and with leukæmia.

Predisposing Causes. Predisposing conditions often exist, such as a hereditary tendency, the strumous and the tubercular constitutions, or chronic disease in the naso-pharynx, *especially adenoid vegetations.* Pre-existing disease in the ear itself is a common predisposing cause. For example, if there be already chronic purulent disease, an acute attack may be excited by some fresh irritation; or, if there be a "dry perforation" remaining after the secreting process has passed away, there is a tendency to a renewal of the old "otorrhœa." So, in simple catarrh of the middle ear, fresh irritation may readily induce an acute purulent condition. The disease may also be due to the extension of an inflammatory process originating in the external auditory canal or tympanic membrane.

Micro-organisms. Recent investigations, especially by Löwenberg, Nether, Zaufal, and Moos, show that purulent inflammation of the middle ear may be due to, or at least associated with, the presence of certain micro-organisms (Fig. 160). These find ready entrance to the cavities of the middle ear through the Eustachian tube or the external auditory canal. The organisms chiefly found associated with these inflammations are the following: (1) Streptococcus pyogenes; (2) staphylococcus pyogenes, albus and aureus; (3) Frænkel's pneumococcus or diplococcus; (4) Friedländer's pneumo-bacillus; (5) the tubercle bacillus. See chapter on "Causes of Ear Disease," p. 51.

Causes of the Persistence of Purulent Inflammation. There are certain circumstances which favour the persistence of purulent disease of the middle ear. (1) The smallness or unfavourable position of the perforation, preventing the escape of the purulent secretion from the tympanic cavity. (2) The formation of exuberant granulations or polypi; these not only perpetuate the discharge, but render it more profuse. (3) Retention and decomposition of the purulent secretion with *formation of cholesteatomatous material* in the upper tympanic cavity or antrum mastoideum. (4) The formation of adhesions or septa, which

may partition the middle ear into several spaces retaining or enclosing part of the secretion, and thus increasing or aggravating the disease. (5) Caries, necrosis,

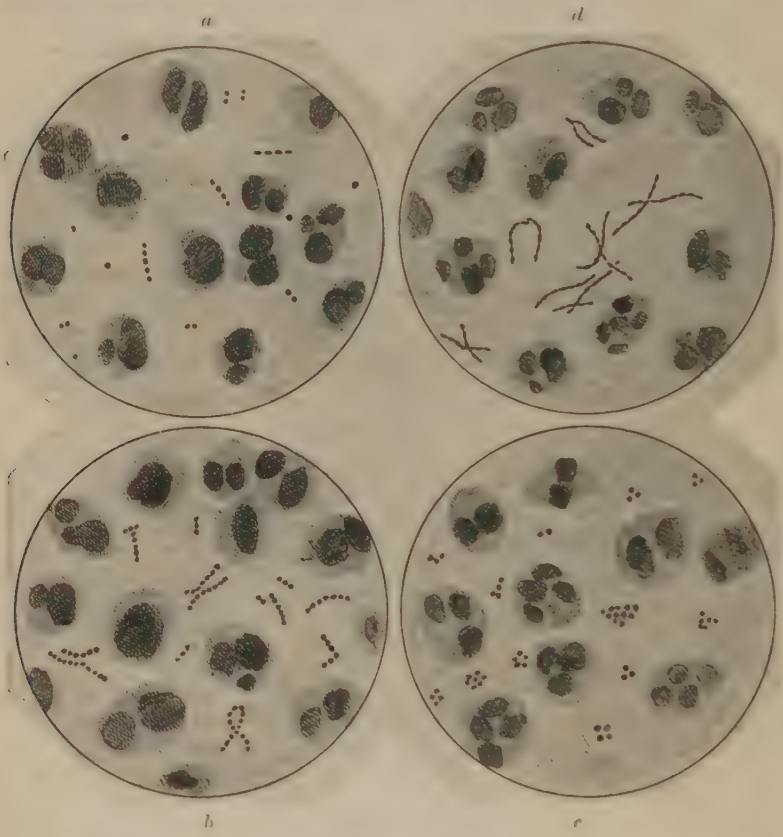

FIG. 160.—Micro-organisms found in purulent discharge from the ear. *a*, Diplococcus from a case of acute purulent inflammation of middle ear with nipple-shaped perforation, after influenza; *b*, streptococcus pyogenes from case of chronic purulent middle ear disease; *c*, staphylococcus pyogenes aureus from a furunculus in the external meatus; *d*, tubercle bacillus from case of chronic purulent middle ear disease in a child.

or hyperostosis of the osseous walls or ossicula. (6) The existence of the tubercular, scrofulous, or syphilitic diathesis, or of bad hygienic conditions. (7) Probably, however, the most important factor in its persistence is the neglect of treatment and especially of proper and thorough cleansing. It is a common experience of those specially engaged in the practice of aural surgery to find persons who have suffered from this disease for many years without any effort having been made to cure it. This is mainly due to the usual absence of pain or disturbing subjective symptoms, to the fact that the morbid processes are concealed from view, to ignorance of the possible consequences of the disease, and to the advice often given by the practitioner to "leave it alone."

SUBJECTIVE SYMPTOMS OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

Pain in the Ear. In the *acute* stage the first symptom usually complained of by the patient is a sense of heat, fulness, and pressure in the ear. Very soon the sensation becomes that of distinct pain, often most intense and penetrating. The pain is felt not only in the ear, but shooting thence along the side of the head as far as the forehead in front or the occiput behind. There may also be a benumbed sensation over the corresponding side of the head. The pain may be less intense during the day, generally becoming very much worse at night and preventing sleep. The pain is usually aggravated during the acts of swallowing, hawking, coughing, blowing the nose, etc. The mastoid process and the glands below the ear are frequently tender on pressure. The pain is usually much relieved when perforation takes place, although cases are not uncommon in which it persists or returns in spite of the rupture of the membrane. It is to be noted, however, that, when this disease occurs during a bad attack of scarlet fever, the gravity of the general symptoms may entirely mask the ear affection, and lead to its being overlooked. It is also to be remembered that cases are met with, not unfrequently, where there is *neither pain nor general disturbance*, when the only indications of the disease are, perhaps, a slight fulness and dulness in the ear followed by a sense of moisture in, or discharge from, the meatus. This is most likely to occur in persons with old perforations, or in those who suffer from tubercular disease.

In the *chronic* stage probably nothing so contributes to the neglect by patients of this disease as the frequent *absence of painful symptoms*. In most cases either there is no pain during the whole course of the disease, or, if pain be experienced, it is at long intervals, and is due to some complication. Thus, obstruction to the exit of the secretion by temporary closure of the perforation, by a polypus, or by contraction of the external meatus, may excite severe pain in the ear. An acute exacerbation may excite great pain; so may also an intercurrent attack of diffuse or circumscribed inflammation of the external meatus. The extension of the inflammation to the mastoid cells or to the mastoid periosteum is usually attended by severe pain in the mastoid region. In the chronic condition heavy dull *pain in the head*, chiefly in the region supplied by the trigeminus, is sometimes complained of, particularly by anæmic and weakly persons. In severe and persistent headache, especially on the side corresponding to the affected ear we should

consider the possibility of extension of the inflammatory process to the dura mater, brain, or venous sinuses.

Subjective Sounds. In the *acute* stage, subjective sounds in the ear, especially those of a rushing or hissing character, are frequently present, while after a few days bubbling or crackling sounds are heard, especially during swallowing or blowing the nose. The patient at this stage usually complains of a painful hammering, pumping, or throbbing in the ear, which can be removed by pressure on the carotid of the same side.

In *chronic* cases subjective sounds in the ear are complained of only in a comparatively small proportion. Chronic purulent disease presents in this respect a striking contrast to chronic non-purulent inflammation. Probably the existence of a perforation, by preventing rarefaction of the air in the tympanic cavity and consequent drawing in of the stapes, accounts for their comparative infrequency in the purulent diseases.

Impairment of the Hearing. There is usually very considerable loss of hearing, especially after exudation takes place. This is most marked when the swelling and exudation specially involve the ossicles, the fenestral recesses, or the Eustachian tube. When the labyrinth shares in the congestive process, the defect of hearing may be extreme.

The degree of impairment of hearing varies from very slight and unobserved dulness to almost complete loss of hearing. It is, in the same person, liable to fluctuation owing to changes in the quantity and the situation of the secretion, and in the degree of swelling of the mucous membrane. It is commonly believed that the defect of hearing is mainly the result of the perforation in the tympanic membrane. *This is a mistake.* There are many persons with perforation of the membrane, even on both sides, whose slightly impaired hearing is scarcely noticed by their friends. The deafness is only partially, and in a comparatively slight degree, caused by the defect in the membrane. It is chiefly due to the following conditions: (1) Swelling or thickening of the mucous membrane covering the ossicles and the fenestral membranes or recesses leading thereto; (2) the presence of fluid or inspissated secretion upon these parts; (3) adhesions or bands connecting the ossicula with the walls of the tympanum, especially the stapes with the walls of its recess; (4) rigidity of the joints of the ossicula, loss of one or more of the ossicula, or loss of continuity in the ossicular chain; (5) a concomitant affection of the labyrinth. In short, if there be a freely movable stapes, with a normal fenestral membrane and a normal nerve, the conducting function of the ear may not be seriously impaired, although the tympanic membrane be destroyed.

The Hearing in the Third or Non-Secreting Stage of the Disease is variously affected. A dry perforation is quite compatible with fairly good hearing. There is not such severe or frequent fluctuation of the hearing as in the secreting stage, while there is not so great a tendency to progressive aggravation of the deafness, or to implication of the labyrinth, as in chronic non-purulent inflammation. A cicatrix does not necessarily cause impaired hearing. If it is large or adherent, there is usually more or less defective hearing, due in the first case to diminished tension of the membrane, and in the second to the adhesion binding the ossicula and impeding their vibrating power. Inflation, in either case, usually improves the hearing, at least for a time. Other kinds of adhesions, connecting bands or cords, or extensive formations of connective tissue, have usually a more important influence in impairing the hearing than a cicatrix. When these exist in the upper part of the tympanum, binding the ossicula to the walls of the cavity or to one another, the hearing may be very seriously decreased. The most serious forms of deafness, which may even be total, are produced by thickenings, or connective tissue formations in the fenestral coverings, by complete binding down or anchylosis of the stapes in its fenestra, and by serious involvement of the labyrinthine structures. It has also to be observed that, when total deafness exists in one ear as the result of chronic purulent disease, the other ear is apt in time to become gradually deaf owing to chronic dry catarrh.

Bone-Conduction. In all stages, with few exceptions, hearing by osseous conduction is much in excess of air-conduction as tested by both Weber's and Rinne's tests. The patient's own voice sometimes sounds to himself with increased resonance on the affected side, *autophonia*, just as when the healthy ear is closed with the finger.

Giddiness. The acute stage is occasionally ushered in with a distinct attack of giddiness, which may also be excited by the pressure of the inflammatory products upon the walls of the middle ear or by concomitant congestion of the labyrinth. In this way the whole series of Ménière's symptoms may result, or there may be frequent attacks of slighter giddiness (see p. 45).

Feverish Disturbance. There is often in the acute stage considerable feverish disturbance with a temperature of from 101 to 103° Fahr., and, occasionally, delirium.

In young children the disease may be manifested in the early stage by great restlessness, by apparent difficulty in sucking and swallowing, and by screaming when the ear is touched or pressed upon. Great disturbance of the nervous system, such as convulsions or coma, is sometimes excited in the young child by an acute inflammation in the middle ear. This might be expected from the anatomical connection which exists in childhood between the mucous membrane of the middle ear and the dura mater (see p. 212).

Sense of Taste and Smell. Patients occasionally complain of impaired or depraved sense of taste. The investigations of Urbantschitsch and others show that impairment of the sense of taste very commonly exists, although rarely complained of by patients.

Occasionally patients speak of a very disagreeable sense of taste and smell, which they attribute to the passing of the fetid purulent matter into the pharynx.

OBJECTIVE SYMPTOMS OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

In describing the objective signs of purulent inflammation of the middle ear, we shall take up the appearances presented (1) in the stage before perforation and discharge, (2) in the stage during which a discharge from the ear exists, and (3) in the stage after the discharge has ceased.

Appearances in the First Stage. At the earliest part of this stage the vessels of the cutaneous layer of the tympanic membrane are found markedly injected, especially over the *pars flaccida*, the manubrium, and the periphery of the membrane (Fig. 161). The other parts may at the same time have a leaden, grey, dull, and lustreless appearance. In severe forms of the disease the individual vessels of the membrane can no longer be distinguished, and the whole surface of the membrane assumes a bright red or bluish red colour.

With the *stage of exudation* the aspect of the membrane changes, owing to its being bulged outwards by the secretion in the cavity of the tympanum, or by interstitial exudation below the epidermic layer of the membrane. The manubrium is no longer visible, owing to the congested cutis and the swollen macerated epidermis which covers it. In some cases the superficial layers of the membrane may be thrown off in thick flakes. Instead of a general bulging outwards there may be partial bulgings (Fig. 162). When the inflammation

Fig. 161.

Fig. 162.

Fig. 163.

Fig. 161. Injection of tympanic membrane at early stage of purulent inflammation of middle ear.

Fig. 162. Elevations of the epidermis of the tympanic membrane seen in certain cases of purulent inflammation of the middle ear in the first stage.

Fig. 163. Saccular bulging projecting from the upper and back part of the left tympanic membrane in the acute stage of purulent inflammation of left middle ear. *a*, Bulging; *b*, inflamed membrane in front.

chiefly affects the attic of the tympanum, the bulging is limited to the pars flaccida. The colour of such bulgings varies in different cases; most frequently they are yellowish or reddish grey, but sometimes they are greenish, and at other times bluish in colour. Saccular bulgings, which are yellowish grey or green in colour (Fig. 163), projecting from the upper and back part of the membrane, may overlap and cover the manubrium, while the rest of the mem-

brane may be but little altered from the normal condition. These saccules may contain serum, blood, or pus; and they may or may not communicate with the cavity of the tympanum. In certain cases, more particularly where the membrane has been already thickened from previous disease, there may be no bulging of the membrane, although exudation is present in the tympanic cavity.

The walls of the external auditory canal are usually somewhat injected and swollen, while the soft parts over the mastoid process are sometimes œdematous or even reddened. The glands behind, below, or in front of the ear may be swollen and tender.

Appearances in the Second Stage. In this stage *the membrane is found perforated*, and the canal of the ear contains *secretion* which has escaped through the perforation from the middle ear.

The Secretion. In quantity this varies in different cases from a slight moisture, which does not escape from the outer orifice of the ear, to an almost constant flow of fluid. At first the discharge may be very thin and copious, resembling yellowish clear serum, becoming afterwards more mucoid or purulent in character. Blood may stain the secretion at this stage. In *otitis media hæmorrhagica*, a discharge of blood at the rupture of the membrane is the leading feature. As the disease progresses the character of the secretion presents great varieties in different cases and in the same case at different times. It may be altogether purulent, white or yellowish in colour, mixing uniformly with water. Or the mucous element may predominate, the secretion being composed of strings or flakes, which do not dissolve in water, but remain floating in it. This mucous secretion is sometimes so tenacious that there is considerable difficulty in completely removing it from the deep parts of the ear (blennorrhœa). Again, the secretion may be rendered thin and less opaque, owing to the pus being mixed with a considerable quantity of serum. The secretion may be tinged with blood, especially when there are granulations or polypi. In caries or necrosis the discharge is sometimes like flesh rinsings (Politzer), and has a very irritating quality. If the discharge be small in quantity, and if there be abundant formation of cerumen, it may be mistaken by the patient for thin wax. In the chronic stages dried masses are sometimes found filling the inner end of the canal and adhering to the upper and back wall. These are composed of epidermic or epithelial laminated masses—cholesteatomata—which may have a shining pearly appearance from the presence of cholesterine between the plates. They generally cover a perforation.

The discharge has frequently an *offensive smell*, unless in the early stages, especially if regular cleansing has been neglected; in spite, however, of regular cleansing the offensive odour may persist.

The odour is particularly offensive when there is diseased bone, or when the secretion remains mixed with the ceruminous and oily matter of the canal. In some cases the odour is disgusting, and infects the air in the neighbourhood of the patient. In very old cases it frequently resembles the odour from rotten cheese, or the odour of old cheese without distinct putridity.

Condition of the External Meatus. In order to ascertain by examination the condition of the walls of the canal and of the tympanic membrane we must, unless the discharge is very slight, syringe the ear, and afterwards dry the parts carefully with absorbent cotton. In the acute stage, plates of sodden epidermis are often found adhering to the walls of the inner end of the canal or to the tympanic membrane. These must be removed. If there is very little discharge, simply wiping it away with cotton wool is to be preferred to syringing. Granulations or polypi may occupy part of the canal, or a polypus may even protrude from the outer orifice. Caries or necrosis of the walls may be found, or the calibre of the canal may be considerably contracted, owing to swelling or thickening of the cutaneous lining or to hyperostosis. The cutaneous lining of the canal is, in many cases, reddish and swollen, from the irritating action of the secretion. We sometimes find, in consequence of the acrid or even caustic properties which the secretion may possess, the skin of the canal, especially of the floor, excoriated, or in rarer cases ulcerated. The excoriation may extend to the outer parts of the ear as far as the lobule. Eczema of the auricle may result from such irritation.

Appearances of the Tympanic Membrane. Perforation. The tympanic membrane is always found in a pathological condition. In the first place there is an aperture in the membrane, forming an abnormal communication between the external auditory canal and the middle ear. This aperture may be no larger than a very small cleft, or a pin point (Fig. 164), or there may be almost complete destruction of the membrane (Fig. 165). In the acute stage, on the removal of the secretion by syringing and wiping, the membrane is found to be very red and swollen, while its normal projections and concavities are effaced, and abnormal bulgings may be seen. The perforation takes place most frequently in the centre of the posterior half of the membrane, when it sometimes appears as a sharply defined black spot (Fig. 164). As it is usually at first small and with more of the character of a minute cleft, it is often

Fig. 164.

Fig. 165.

Fig. 164. Perforation in left tympanic membrane during acute suppuration of middle ear. *a*, Short process of malleus; *b*, perforation.

Fig. 165. Showing almost complete loss of membrane. *a*, Short process; *b*, articulation of incus with stapes; *c*, remnant of membrane.

difficult, or impossible, to distinguish it in the swollen inflamed tissue. In certain cases characterized by great persistence, we find the perforation, minute in size, situated at the apex of a nipple-shaped projection (Fig. 166), springing usually from the upper part of the membrane and projecting downwards. Even in an acute case, however, the perforation may be large, involving the greater part of the membrane, and this is likely to be the case if it has originated in scarlet fever or is based on an old perforation. There is probably never *complete loss of the membrane.* Even in the worst cases, which have generally their origin in scarlet fever, a portion of the upper segment and a narrow rim all round usually remain, although these remnants may be difficult to see owing to the swollen state of the tissues. Between the pin-point perforation and almost complete destruction, we find great varieties in the extent of loss of the membrane. There is usually only one perforation, but occasionally two are found (Fig. 167), and very rarely three.

Situation and Shape of the Perforation. Probably the most common situation in which a perforation is found is the lower half of the membrane. Perforations are, however, not at all uncommon in the upper part, especially when the source of the secretion is in the attic. The perforation is then commonly in the *membrana*

Fig. 166.

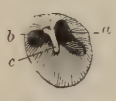

Fig. 167.

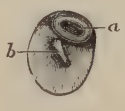

Fig. 168.

Fig. 169.

Fig. 166.—Nipple-shaped perforation in tympanic membrane.

Fig. 167.—Double perforation in left tympanic membrane. *a*, Larger perforation behind manubrium; *b*, smaller perforation in front of manubrium; *c*, lower end of manubrium.

Fig. 168.—Destruction of membrana flaccida. *a*, Aperture in membrana flaccida; *b*, manubrium pushed down and shortened.

Fig. 169.—Large oval perforation in anterior half of tympanic membrane. *a*, Near centre of perforation; *b*, short process of malleus.

flaccida (Fig. 168). The aperture may in these cases be exceedingly small, and situated close to the upper edge of the Rivinian segment; or the whole of the membrana flaccida may be removed with a portion of the bony edge of the Rivinian segment. When the antrum mastoideum is the source of the secretion, the perforation is generally in the postero-superior part of the membrane. Perforations in the tympanic membrane are most frequently roundish or oval in shape (Fig. 169). When the lower end of the manubrium projects into the gap, the latter has a *kidney shape* (Fig. 170), with the *hilum* upwards.

The Remnant of the Tympanic Membrane. The portion of the tympanic membrane which remains presents various appearances. It may, especially in the early stage, be congested and swollen. At other

times it is greyish or whitish and hypertrophied. Sometimes there is a well defined calcareous patch. This is, however, most frequently seen after the purulent process has ceased. There may be in the one membrane several patches of calcareous deposition, and even the whole of the remnant of the membrane is sometimes found converted into a chalky mass. The edge of the perforation is often red and granular, and in contact with, or even adhering to, the inner wall of the tympanum or to one of the ossicula (Fig. 171).

Fig. 170.

Fig. 171.

Fig. 170. Kidney-shaped perforation. *a*, Manubrium; *b*, perforation.

Fig. 171. Round perforation in centre of right tympanic membrane. The upper edge of the perforation is adherent to the inner wall of the tympanum. The lower half of remnant of membrane is converted into a calcareous mass. *a*, Perforation; *b*, calcareous mass; *c*, portion of short process of malleus.

Interior of the Tympanum as seen through the Perforation. The mucous membrane of the tympanic cavity, as seen through the perforation, is generally red and swollen or even hypertrophied, and the surface may be either smooth or granular. Granulation tissue or a polypus often sprouts from the inner wall or from the edge of the perforation, and may thus cover and conceal the perforation. Sometimes, especially in very old cases, the tympanic wall is yellowish grey or whitish in colour, or part of the exposed mucous membrane may be red and swollen and part grey and thinned.

The part of the cavity of the tympanum exposed to view depends upon the size and position of the gap in the membrane (Fig. 172). The mucous covering of the *promontory* immediately behind and below the umbo is very frequently laid bare. In the postero-inferior quadrant we often see the anterior rounded edge of the opening into the fenestra rotunda, and behind that the opening itself is seen as a dark semi-lunar depression directed backwards (Fig. 173). When the lower part of the membrane is destroyed, the irregular tesselated appearance of the floor comes under observation; while, if the loss of membrane is in the antero-superior part, the portion of the inner wall corresponding with the position of the carotid artery and, more rarely, a part of the entrance to the Eustachian tube are exposed.

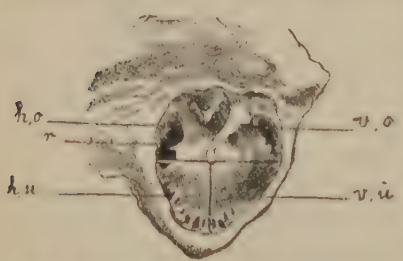

Fig. 172. View of inner wall of tympanum divided into four parts, tympanic membrane (not manubrium) being removed. *v.o*, Antero-superior quadrant; *v.u*, antero-inferior quadrant; *h.o*, postero-superior quadrant; *h.u*, postero-inferior quadrant; *r*, niche of the fenestra rotunda.

One or more of the Ossicula may be clearly seen through the aperture. When the membrana flaccida is destroyed, the neck of the *malleus* and sometimes a part of its head are brought into view. The *manubrium* may be apparently thicker than in the normal

condition, and the lower end in contact with the inner wall of the tympanum, or even immovably fixed to it by adhesions. In many cases, however, it is shortened, owing to carious destruction of the lower part (Fig. 173), and sometimes nothing remains but the short process and a small part immediately below, both much thickened, or it may be entirely invisible. But the manubrium may be invisible or appear shortened, not because of its destruction, but because of displacement upwards. This is due to its having lost the support of the tympanic membrane, so that the tensor tympani muscle, being no longer antagonized, pulls the malleus so far upwards and inwards, that it comes to lie in the attic and so disappears from view. In destruction of the upper and back part of the membrane the *long process of the incus* and its articulation with the head of the *stapes* are not unfrequently seen (Fig. 172), although, even when the stapes is exposed, this process of the incus may be wanting. Rarely is the long process of the incus exposed to view, with no part of the stapes visible. The *knob-shaped head* of the stapes may alone be seen, or, in addition, one or other of the crura, particularly the posterior, may be visible (Fig. 174), when the tendon of the stapedius muscle is sometimes observed extending from the head of the stapes towards the back wall of the tympanum.

Fig. 173.

Fig. 174.

Fig. 173.—Large destruction of right tympanic membrane, showing promontory and entrance to fenestra rotunda, only upper part of membrane with portion of manubrium remaining. *a*, Entrance to fenestra rotunda; *b*, front of promontory; *c*, a part of membrane remaining with upper half of manubrium.

Fig. 174.—Large destruction of right tympanic membrane, exposing portion of stapes, entrance to fenestra rotunda, and promontory. *a*, Short process of malleus; *b*, calcareous deposition in part of membrane remaining; *c*, entrance to fenestra rotunda; *d*, above and in front of promontory; *e*, head and crura of stapes

Glandular Structures. Enlargement and tenderness of the glands in the neighbourhood of the ear are often found associated with purulent disease of the middle ear. The cervical glands below the ear, the parotid, and the glands over the mastoid process may be affected in this way. Suppuration or tubercular infiltration, especially in the cervical glands, not unfrequently results.

In the Third or Non-secreting Stage we often find, if the perforation has closed, injected vessels radiating from the centre to the circumference with hyperæmia of the manubrium and membrana flaccida. Later on there is a dulness, flatness, and slight opacity or want of lustre of the membrane. In many cases, especially after an attack of short duration, there is no evidence of any deviation from the normal condition; in others a slight indentation is seen corresponding with the seat of the past perforation, or there may be a depression, representing an adhesion to the inner wall of the tympanum. In others a general opacity of the tympanic membrane is left behind.

A Cicatrix—Calcareous Deposit. In cases which have pursued a chronic course a well-marked *cicatrix* is frequently seen (Fig. 175). A cicatrix in the membrane is dark in colour; its edge is sharply defined, while it is much thinner than, and, on that account, is depressed below the level of, the rest of the membrane. When the middle ear is inflated, or when the air in the external meatus is rarefied, the cicatrix is seen to bulge out somewhat like a small bladder, which, however, collapses immediately afterwards. The membrane adjoining a cicatrix is frequently *opaque* and *thickened*, and it may be the

FIG. 175.

FIG. 176.

FIG. 177.

FIG. 178.

FIG. 175.—Permanent cicatrix in tympanic membrane, after acute purulent inflammation of middle ear. *a*, Cicatrix; *b*, manubrium.

FIG. 176.—Left tympanic membrane in which there is a cicatrix, including the posterior superior part; through the transparent cicatricial portion is seen, above, the articulation of the incus and stapes; below, the rounded border of the entrance to the fenestra rotunda. The cicatricial membrane lies in contact with these parts. *a*, Centre of cicatricial part of membrane.

FIG. 177.—The same membrane immediately after inflation, by Politzer's method, showing the bladder-like bulging of the cicatricial portion. *a*, Centre of cicatricial part; *b*, short process of malleus.

FIG. 178.—Right tympanic membrane after long-continued suppurative process had passed away, showing cicatrix and large calcareous deposition. *c*, Cicatrix; *b*, calcareous deposit; *a*, short process of malleus.

seat of a calcareous deposit. If the cicatrix be large, we may see through it parts of the inner wall of the tympanum and of the ossicula. The promontory, the opening into the fenestra rotunda, or the articulation of the incus and stapes, may then be clearly seen, as if through a perforation (Fig. 176). The cicatrix may in some cases form adhesions with these various parts, and this may be ascertained by the use of the pneumatic speculum. If we inspect the membrane during the act of inflation, a bladder-like bulging of the cicatrix (Fig. 177) with mobility of the rest of the membrane shows the absence of adhesions. Along with a cicatrix there is often a *calcareous deposit* (Fig. 178) in the neighbouring parts of the membrane. This is usually white or whitish yellow in colour, semilunar in shape, and, like a cicatrix, clearly demarcated from the neighbouring membrane. We may find several calcareous patches, and frequently one is seen in front of the handle of the malleus, and another behind.

Dry Perforation. One of the commonest conditions, especially after a long continued discharge, is a *dry perforation*. In these cases the edge of the perforation is usually thickened and callous, and has an epidermic covering. The mucous membrane of the tympanic cavity, especially of the promontory, as seen through the perforation, is generally dry, greyish, and shining, consisting of cicatricial tissue. The remnant of the membrane or, it may be,

the mucous membrane of the middle ear, is here also frequently the seat of calcareous deposit, opaque thickening, or circumscribed atrophy. In a large number of persons in the community such changes are found—the effects of an old discharge dating it may be from childhood, the existence of which is often unknown to the individual.

COURSE AND CONSEQUENCES OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

The Duration and Mode of Termination of the First Stage. The interval between the beginning of the symptoms and the rupture of the tympanic membrane varies in different cases. It may be as short as a few hours or as long as two weeks. In most cases, however, the rupture takes place in from three to four days. During this time the pain is usually intermittent, sometimes after the first day it disappears altogether. This stage is likely to be shorter if a perforation or a cicatrix already exists. On the other hand, the rupture may be delayed owing to the membrane having previously undergone morbid thickening, or become the seat of calcareous deposition. In children the tympanic membrane is normally thicker than in adults, and therefore offers resistance for a longer time to the pressure of secretion pent up in the tympanic cavity. The rupture may take place by ulceration of the membrane, or the latter may be so thinned and weakened by the pressure of the fluid and the softening effect of the inflammation, that a slight additional pressure, such as may take place during coughing or sneezing, is sufficient to burst it. A hissing sound in the ear and a discharge of fluid, often tinged with blood, usually signalize the rupture, while marked relief to the pain and the other subjective symptoms is, in most cases, immediately experienced. This relief, in children, is often very remarkable both in the completeness and suddenness with which the subjective symptoms disappear. Sometimes, however, little or no effect in relieving the pain follows the rupture, or the relief may be temporary, owing to the intensity of the inflammatory process, obstruction to the escape of secretion, or the occurrence of mastoid complication.

The Duration and Consequences of the Second Stage. The period from the rupture of the membrane to the healing of the perforation may be no longer than from three to four days. It is found sometimes that the perforation closes almost immediately after the escape of some serous fluid, leaving only a mark of blood at the site of the aperture. In many cases cicatrization takes

place within two weeks; but the general health, the habits of life, and especially the character of the treatment, influence very materially the duration of this stage. Some cases terminate in a few months, a large number only after many years, while a certain proportion of cases *continue for a life-time*. The discharge may be constant, but there are, in a considerable number, occasional intermissions of days, weeks, or even months. It is usually aggravated in spring or early winter, or when the patient suffers from cold in the head. During the continuance of this stage certain complications may arise. *These are so important in their nature, and demand such full consideration, that they will be discussed separately and in detail in Chapters XII. and XIII.*

These consequences will be described in the following order:

I. Consequences limited to the ear and Fallopian canal.
   - *A.* Polypi of the ear.
   - *B.* Affections of the mastoid process.
     - (*a*) Acute mastoid periostitis.
     - (*b*) Acute purulent collections in the mastoid cells.
     - (*c*) Chronic processes (resulting from purulent disease) in the mastoid cells, antrum, and attic.
   - *C.* Facial paralysis.

II. Intra-cranial and vascular infective complications of purulent inflammation of the middle ear.
   - *A.* Cerebral and cerebellar abscesses.
   - *B.* Meningitis (pachy-meningitis, lepto-meningitis, tubercular meningitis).
   - *C.* Septic thrombosis of the sigmoid sinus and other intra-cranial venous sinuses (pyæmia, septicæmia, metastatic abscesses).
   - *D.* Embolism, tuberculosis, hæmorrhage.

How the Purulent Process terminates. The purulent process, after a lapse of time varying from several days to many years, may permanently cease, leaving, however, in most cases the organ more or less injured. We may conveniently distinguish three groups of cases to illustrate the various modes in which the purulent process may terminate and the condition in which the organ of hearing is left. (1) Those in which the inflammation of the mucous membrane gradually subsides, with diminution and, ultimately, complete cessation of the secreting process, terminating in closure or cicatrization of the perforation and recovery of the function of the organ. This course is common in cases of short duration, and by no means a rare one in chronic cases. (2) Those which terminate, like the first group, in cessation of the purulent process and complete cicatrization of the perforation, but where

permanent damage to the hearing is left behind from thickening and rigidity of the mucous membrane, from adhesions or bands in the cavity of the tympanum, or from thickening, calcification, or atrophy of the tympanic membrane. (3) Where there is recovery from the chronic purulent process, but *persistence of the perforation*, the so-called "dry perforation," with more or less injury to the hearing, mainly from the same causes as in the second group.

Healing by Cicatrization of a long existing perforation in the tympanic membrane is not at all unfrequent. While it is rare for almost total destruction of the membrane to end in the formation of a cicatrix which completely fills up the gap, such a result has been observed. Small or moderate-sized perforations, however, not unfrequently heal, even after they have existed for many years. There is usually left behind a permanent cicatrix, consisting of a thin layer of connective tissue having an epithelial covering both on its outer and inner side. It is sometimes found that after a perforation has cicatrized the hearing is less acute than before. This possibility should not, however, deter us from using every means to bring about healing. If the hearing be worse after cicatrization, it may ultimately improve either spontaneously or as the result of treatment.

Dry Perforation. In a considerable proportion of cases, however, the perforation remains open, the so-called "dry perforation," after the purulent process has ceased. We are not able to explain satisfactorily why in one person a perforation may completely cicatrize, while in another a perforation of equal size, and apparently under similar circumstances, may never cicatrize. It is to be noted, however, that cicatrization may take place years after the cure of the discharge. When a permanent "dry perforation" remains, the patient is more exposed to attacks of acute purulent inflammation than when cicatrization has closed the opening. This liability is due to loss of the protective power of the membrane and exposure of the tympanic mucous lining to injurious influences from without, such as cold wind, water trickling into the ear, etc.

Permanent Structural Changes left behind by the Purulent Process. Adhesive processes, or formations of bands of connective tissue, very frequently take place during some part of the course of a case of chronic purulent inflammation of the middle ear. From prolonged contact of soft, inflamed, granulating mucous surfaces, permanent adhesions may form, especially between the tympanic membrane and the inner wall of the tympanum, or between the tympanic membrane and the incus and stapes. Adhesions, bands, or cords may partition off the middle ear into two or more compartments, having no communication with each other. In this way we may have the upper tympanic space shut off from the lower or from the Eustachian tube, or the anterior part of the tympanum from the posterior. Membranous septa may in some instances

completely shut off the antrum mastoideum, in others the Eustachian tube, from the cavity of the tympanum. In like manner the recess into the fenestra rotunda may be completely closed. Cords or bands may also bind the ossicular chain or individual bones of it, and so diminish or destroy their vibrating or conducting power. The stapes is in this way frequently bound to the walls of the fenestra ovalis, or the handle of the malleus to the promontory. Cases are also met with, in which the fenestral recesses are filled with connective tissue, the stapes being thereby rendered absolutely immovable, and access to the membrane of the fenestra rotunda shut off. Loss of continuity in the ossicular chain, by the exfoliation of the incus or its separation from the stapes, is also a not uncommon result. In consequence of these changes, after the secreting process has come to an end, the hearing may remain much impaired, although a permanent dry perforation is quite compatible with fairly good hearing if there are no other changes. As has been already indicated, there is not such severe or frequent fluctuation of the hearing as in the secreting stage, while there is not such a tendency to progressive aggravation of the deafness, or to implication of the labyrinth as in the chronic non-purulent forms.

Permanent changes may also take place in the external auditory canal, such as stenosis from cutaneous thickening, adhesions, false membranes, or hyperostosis. In certain cases also (panotitis) the labyrinth may be permanently damaged by the purulent process.

DIAGNOSIS OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

Diagnosis in the Stage before Perforation. When, as is too frequently the case, no examination is made of the interior of the ear, purulent inflammation may be readily overlooked, especially *in the acute stage*, and the disease may be confounded with some other condition. The pain in the ear and in the side of the head is sometimes looked upon, especially in children, as toothache or as neuralgia connected with diseased teeth. This mistake may lead to serious blunders in treatment, such as the prescribing of quinine, a medicine which may act injuriously in acute inflammation of the middle ear. A large number of the so-called *earaches* are really cases of this disease.

In the acute stage this disease is undoubtedly sometimes looked upon as meningitis, or congestion of the brain. If the physician trusts to subjective symptoms alone, it is easy to see how, especially in the case of a child, such a mistake may be made. The pain which, even in an adult, may be described as being more in the side of the head than in the ear; the giddiness, the stupor or delirium, the convulsions, may readily, in the absence of objective examination of the ear, be regarded as pointing to inflammation in the interior of the cranium. The impairment of hearing, being usually limited to one side, may pass unnoticed, and thus no suspicion of aural disease may be entertained. When the inflammation occurs during an exanthematous disease, especially during scarlet fever, it

is particularly liable to escape detection, being masked by the graver general disease. It is to be remembered, on the other hand, that the inflammation may extend in the child to the membranes of the brain through the petro-squamosal fissure. An objective examination will at once remove any doubt. Obscure illnesses in young children, consisting of feverishness, irritability, and symptoms of cerebral disturbance, are sometimes explained by the ultimate appearance of a discharge from the ear.

When the *second* stage with discharge has been reached, the diagnosis depends very much upon the existence of a perforation in the tympanic membrane.

Diagnosis of a Perforation in the Tympanic Membrane. The presence of a perforation in the tympanic membrane is generally easy of recognition.

In the first place, it may be said that, if a person has suffered from a purulent discharge from the ear, there is *great probability* of a perforation; while, if the discharge contains mucus, there is undoubtedly an abnormal communication with the middle ear, and this communication will consist in nearly all cases of an opening in the tympanic membrane. We have already described the appearances and the usual situations of these perforations. We may here mention certain difficulties in the diagnosis of a perforation, which may present themselves. (1) If it be very small, and in a membrane which is much reddened and swollen, and especially if it be situated in the lower and front part, which is often concealed by the bulging of the antero-inferior wall of the external auditory canal, there may be great difficulty in distinguishing the perforation by inspection alone. (2) When the opposite condition exists, that is, when the membrane is almost totally destroyed, the red and swollen mucous membrane of the inner wall of the tympanum may be confounded with an inflamed tympanic membrane. (3) In cases of moderately sized perforations where the edges of the perforation are in contact with, or adhering to, the inner wall of the tympanum. (4) When the membrane, either in whole or in part, is so transparent owing to its having become atrophied or converted into cicatricial tissue, and lies so close to the inner wall of the tympanum, that the parts inside the tympanum opposite the membrane are seen as if no membrane existed (Fig. 176). If the transparency is limited to a part of the membrane, it is particularly apt to be mistaken for a perforation. If secretion exist in the tympanum opposite the atrophied part, the appearance may be strikingly like that of secretion seen through a perforation.

Inflation in the Diagnosis of a Perforation. In any of these conditions inflation of the middle ear, by Politzer's or Valsalva's

method, is the most important aid to diagnosis. If the perforation be small, a *hissing* or *whistling* sound is heard during inflation, usually so distinct as to be heard even by a bystander; or, if auscultation be employed, it may be so loud as to be painful to the ear of the surgeon.

By inspecting the interior of the ear during inflation, if there be secretion in the tympanic cavity, we are usually able to see secretion mixed with bubbles of air projected from the orifice in the membrane. When there is only a small perforation, especially if of the nipple-shaped variety, while the pus contained in the tympanic cavity is very thick, we may find on inspecting the interior of the ear during the attempt to inflate by Valsalva's method that only a drop of thick pus appears at the orifice, without the passage of air, and when the effort to inflate has ceased the drop of pus recedes again into the tympanic cavity. If we find, after inflation, air bubbles in the inner end of the canal, which were not there before inflation, we may assume the existence of a perforation; or if, after removing all secretion and then inflating, we find secretion in the inner end of the canal, we may be assured that there is a gap in the membrane.

When the difficulty in diagnosis is due to the edge of the perforation being in contact with, or adhering to, the ossicles or the inner wall of the tympanum, examination of the membrane during inflation of the middle ear, or during suction by the pneumatic speculum, will usually aid materially in the diagnosis of the case. In like manner the actual condition present in transparency of the membrane from atrophy or cicatrization is at once shown by the bulging outwards of the thinned membrane during inflation or suction (Fig. 177). If the perforation consist of a simple fissure in the membrane, the separation and moving outwards of the edges of the fissure during inflation will ensure its recognition.

By Auscultation during inflation, when there is almost complete loss of the membrane, and when the mucous lining of the tympanum and Eustachian tube is swollen and partially covered with secretion, we can usually make out the loud hissing or whistling sound. When, however, there is neither swelling nor secretion, the sound is an exaggeration of the normal auscultation sound, being full and blowing, and giving the impression of being produced in the auscultator's ear.

It is to be remembered, however, that we sometimes cannot inflate the middle ear, in consequence of great obstruction in the Eustachian tube from swelling of its mucous membrane, adhesions, etc. Or there may be adhesions in the tympanic cavity, which prevent the current of air reaching the perforation. On the other hand, if

the Eustachian tube be freely open, we may find persons able, by Valsalva's method, to expel a current of air of strength sufficient to affect a light held opposite the ear; and, if a manometer be fixed in the canal of the ear, the fluid in the manometer may be forced completely out of the tube. We sometimes meet with individuals who can force tobacco smoke from the throat out of the ear. In cases of almost complete destruction we usually see, after syringing and careful drying, the narrow rim of membrane at the margin, especially in the situation of the membrana flaccida. If this be not seen, we may observe a cleft or fissure in the situation of the periphery of the membrane.

We occasionally get information of the existence of a perforation, while syringing the ear before examination, by the remark of the patient that he *feels the injected liquid in his nose or throat*, and we may in such cases even see the fluid escaping from the nostrils.

A pulsating movement is frequently observed in secretion or other fluid lying over the membrane. This in the great majority of cases denotes a perforation. The movement is due to pulsation in the small arterioles of the inflamed mucous membrane of the tympanic cavity causing a rhythmical rising or falling, or sometimes a lateral movement, of the secretion in contact with it. The pulsation is generally most marked when the perforation is small, and it is also most distinct in spots where there is a special reflection of light. It is to be remembered, however, that pulsating movements are occasionally seen when the membrane is certainly intact.

PROGNOSIS OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

In viewing the prospects of a patient who suffers from this disease, we must take into account the possible consequences and complications, both to the structures within the ear and the organs outside of it, which may attend this affection. Such a consideration will impress us with the truth of Wilde's oft-quoted saying that, "*when a discharge from the ear exists, we can never tell how, when, or where it will end, or to what it may lead.*"

Amount of Structural Damage. In estimating the prognosis we must consider the amount of damage inflicted upon the structures of the ear. If there be almost complete destruction of the tympanic membrane, a permanent perforation may be anticipated. This always exposes the tympanic cavity to injurious influences from without, and thus tends to encourage the recurrence of the purulent inflammatory process. When there is a small perforation, on the other hand, especially if of the nipple-shaped variety, there may be

considerable difficulty in curing the disease; but, when it is cured, there is much less tendency to recurrence. If granulations, polypi, or great thickening of the mucous membrane exist, the purulent process will continue until the removal of these conditions; the frequent recurrence, after removal, of granulation tissue and polypi may denote the presence of caries or necrosis. Adhesions or false membranes in the tympanum, or stricture of the Eustachian tube or external auditory canal, are unfavourable circumstances, owing to the hindrances which they present to the escape or removal of the purulent secretion, and to the application of healing agents. Carious disease of the bone is of serious import if it affect the *partitions between the middle ear and the interior of the cranium, or the canals for the large blood-vessels*, by exposing the patient to the danger of extension of the disease to the meninges, sigmoid sinus, or brain, leading to a fatal issue. Necrosis is not so formidable a complication, for, by the removal of the sequestrum, the cure of the discharge is generally achieved.

The Source and Character of the Discharge are important considerations in the prognosis. If the *source* of the secretion be in the attic, antrum mastoideum, or mastoid cells, especially with only a small perforation in the membrana flaccida, the difficulty of curing the discharge and the danger of serious complications are much greater. On account of the anatomical formation of the parts, the complete removal of the secretion is extremely difficult, and stagnation, accumulation, and decomposition of the purulent products form a constant menace to the life of the patient from septic absorption or extension to the interior of the cranium. Disease of the bone and injury to the facial nerve in the Fallopian canal are also more likely to be produced by the disease, when chiefly confined to these localities. The *character* of the secretion may throw light upon the prognosis. If the discharge be thick, with a small perforation, the case is likely to be lingering. An offensive odour, which is strong and persistent in spite of frequent and thorough cleansing, raises the suspicion of diseased bone. When the discharge is composed chiefly of copious, stringy mucus (blennorrhœal discharge), with a pretty large perforation (frequently seen in children), the case is likely to be obstinate and persistent.

The State of the Hearing Function may supply useful information. If the hearing be not very defective, and if it be improved considerably by cleansing and inflation, the obstacles to the conduction of sound are probably remediable. If there be great deafness, with severe subjective sounds not relieved by inflation, and if there be also defective perception of sound by osseous conduction, there is small prospect of improvement in hearing, although the secreting

process may be put an end to; either the fenestral structures or parts of the labyrinth are involved.

The Cause of the Disease, its duration, and the results of treatment must be taken into account. When it originates in diphtheria, scarlet fever, or tubercular disease, or when associated with a strong hereditary tendency to ear disease, it is often specially obstinate. In most cases, the longer the disease has existed the more difficult is its successful treatment. The failure of long-continued judicious treatment must be looked upon as an unfavourable omen.

The Constitution of the Patient, as well as his avocation, habits, and position in life, influences our prognosis. The strumous, tubercular, and syphilitic constitutions must be regarded as highly unfavourable to rapid or complete recovery. In the strumous patient diseased bone and glandular enlargements or suppurations are more frequent complications; in the tubercular, rapid but painless softening and destruction of the membrane and intractability to local treatment are marked features; while in syphilis, labyrinthine complication is not unfrequent. The course of the disease is also naturally less favourable in persons who are frequently exposed to inclement weather with insufficient protection, or in ill-fed and ill-tended children.

Relation to Longevity. A very important question may be asked, *What proportion of patients, who suffer from chronic purulent disease of the middle ear, have their lives cut short thereby?* This is a question regarding which our information is still meagre. With the increased interest in diseases of the ear taken both by the public and by the profession, and especially as the result of fuller and more correct knowledge of the serious consequences which are apt to attend them, we may soon be in a position to give at least an approximate answer to this question. Von Tröltsch and others assert, as the result of their observation of large numbers of aural patients, that sufferers from otorrhœa have not the average duration of life, and that they frequently fall victims at a comparatively early age, either to the direct consequences of the disease, or to phthisis or other wasting disease. It is noteworthy, at all events, that while this disease comes extremely frequently under our notice in children and persons before middle life, we meet with it comparatively rarely after middle age, either in the actually secreting form or in the stage of "the dry perforation" with impaired function of the organ, a condition in which, considering the great frequency of the secreting stage of the disease in early life, we would expect to find very many aural patients who have passed middle life.

Relation to Life Insurance. This leads us to the consideration of a question which has been discussed of late years, namely, whether a person who suffers from chronic discharge from the ear should be accepted by an insurance company. Von Troltsch was of opinion that its significance in relation to life assurance is as serious as many cases of valvular heart disease, tubercular disease of the lung, or hernia. Without attributing to it any such importance as that of organic heart disease or phthisis, the writer thinks its existence in an applicant for insurance should be taken into account in calculating the probable duration of life, and that forms of proposals issued to intending insurers should contain the question, "Is there or has there been any long-continued discharge of matter from the ear?" The unfavourable points requiring consideration in deciding upon the degree of gravity of any particular case have just been referred to. The effects of treatment are probably of greatest importance in deciding the suitability for life assurance. If treatment has been attended by complete cicatrization of the perforation, the life may be accepted without reservation. If, however, a dry perforation has been left behind, although the purulent process has been cured, the risk of recurrence of the disease should be met by some addition to the annual premium. On the other hand, if rational and long-continued treatment has failed in putting an end to the purulent process, acceptance should be postponed or a considerable addition made to the premium.

Are sufferers from chronic discharge from the ear fit for military service? When we consider the tendency in this disease to acute inflammatory attacks, which would incapacitate a soldier for duty, the fluctuating condition of the hearing, and the possibly serious consequences to life itself, the writer thinks it would be proper in the interests both of the individual and of military efficiency to exclude persons suffering from this disease from such a life of exposure as that of a soldier in the field.

CHAPTER XI.

TREATMENT OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

TREATMENT OF THE FIRST OR ACUTE STAGE—BEFORE PERFORATION OR DISCHARGE.

In deciding upon the kind of treatment to be adopted we must have regard to the severity of the attack, and especially to the intensity of the subjective symptoms.

Local Abstraction of Blood. In a severe attack, signalized by great pain and occurring in a healthy adult, local abstraction of blood followed by warm applications is of great value, especially in the early stage (see "Local Abstraction of Blood," p. 65). In an adult four leeches should be applied—two over the tragus and two at the lower part of the mastoid process. If the symptoms be less acute one leech in each of these situations will suffice. In a young child one leech applied over the tragus gives sufficient depletion. Pain and throbbing in the ear are usually decidedly mitigated by this treatment. The good effects are enhanced by the use of hot sponge fomentations after the bleeding has ceased. The artificial leech of Heurteloup (see p. 66) may in some cases be conveniently employed.

Warm Applications. In milder cases, when the pain and subjective symptoms are less severe, or in anæmic or debilitated persons, local bleeding may be unnecessary or undesirable; warm applications are then of great service. A sponge or piece of folded lint, pressed out of hot water, placed closely over the ear, and covered with impermeable material, has often a very soothing effect. Simple *warm water* (102° F.) poured into the ear from a teaspoon, renewed every few minutes, usually gives relief; or a continuous stream of warm water, flowing from a jug through a tube of india-rubber introduced into the ear, on the syphon principle, may be more efficacious. *Warm poultices* of linseed meal applied over the ear and side of the head often afford great relief and comfort. It is found, however, by experience that their long-continued use tends

to produce softening and ulceration of the deep parts of the ear, especially of the tympanic membrane, and also encourages the growth of exuberant granulations and even polypi in a short space of time. A small, warm, conically-shaped poultice, filling the concha and outer orifice of the ear, is not so likely to be followed by these undesirable results. While, therefore, the large poultices may be applied with advantage when the pain is at its height (if the warm water or the small conical poultices do not sufficiently relieve it), we should instruct the patient to discontinue their use as soon as the pain is relieved. *Breathing into the ear*, and holding the ear over hot water so as to allow of the entrance of the vapour, are simple and useful remedies.

Medicated Applications are often useful. In an adult, 10 drops of a solution of morphia (2 grs. to an oz.), warmed and instilled into the ear every three or four hours, may have a more sedative effect than the warm water. A small plug of cotton wool moistened with the same solution and inserted into the outer canal of the ear is in some cases preferable. At other times a few drops of a warmed solution of belladonna and opium, such as Formula 69, or of the more popular tincture of opium, placed on a pellet of cotton wool and laid in the outer orifice of the ear, forms a convenient and efficient sedative application. The solution of atropine (2 grs. to the oz.) is recommended by some authors, but this must be used with caution. Hewitson speaks highly of the soothing effects of carbolic acid and glycerine (Formula 87), to which may be added cocaine (Formula 88). The gelatine preparations of Gruber are also worthy of trial for the relief of pain (see p. 172).

Soothing embrocations, containing belladonna, aconite, chloroform, and opium (Formula 70), applied to the neighbourhood of the ear, will assist in allaying the pain, which often extends along the temple and side of the head. Menthol, chloroform, and olive oil (Formula 73) also form a good embrocation for this purpose. Politzer recommends the application of equal parts of chloroform and olive oil: 20 or 30 drops are sprinkled over a piece of cotton wool the size of the palm of the hand, and this is laid over the ear.

Vesicants are frequently used behind the ear by practitioners. Their utility is doubtful, and they have the disadvantage of masking the onset of mastoid mischief. Gruber and Roosa, however, believe that they relieve pain.

Internal Sedatives. In some cases, where the pain is of so intense a nature as to prevent sleep, an internal sedative may be required, such as a full dose of the solution of morphia for an adult, or a dose of Dover's powder for a child. In an adult the subcutaneous injection of morphia may sometimes be called for.

Bromide of potassium or hydrobromic acid is useful where there is much nervous irritation. Phenacetin often relieves pain, while sulphonal promotes sleep. When there is marked febrile disturbance a warm bath, or medicinal diaphoretics, such as Dover's powder or the solution of acetate of ammonium, with the addition of a saline laxative, are indicated. Antipyrin may, in some cases, be more efficacious than these older remedies.

Precautionary Measures. Light diet and abstinence from alcohol and tobacco are wise precautions, while rest and quiet in the house conduce very much to a favourable issue, especially during winter or cold weather. Recurrence of the disease, as well as serious complications, is often due to exposure and fatigue. In order to prevent the action of cold air, loud sounds, etc., upon the inflamed organ, a plug of antiseptic cotton wool should be worn in the ear, with a pad of cotton wool covering the auricle, while the inflammatory process is present. During winter time, and especially if there is cold wind, a plug of cotton should be kept in the ear for a time after the attack has passed off.

In an infant perfect quietness, absence of strong light, rest in a comfortable position, and the avoidance of pressure on the affected side, are precautions which should not be neglected. If cerebral symptoms arise appropriate remedies should be employed, such as bromide of potassium, cathartics, the application of cold to the head, etc. We must in these cases be careful to prevent the trickling of cold water into the ear from cold applications to the head.

Incision of the Tympanic Membrane. When there is distinct evidence of a purulent collection in the middle ear, indicated by severe pain not relieved by the foregoing treatment, and by a yellowish bulging of the membrane, or a saccular elevation upon it, incision of the membrane should be performed (see "Incision of the Tympanic Membrane," p. 74). When we have such a cavity as the tympanum filled with pus, whose walls consist partly of bone and partly of fibrous tissue, situated in the immediate neighbourhood of most important structures, opening with the knife is simply in accordance with the clearest surgical principles, and may be of importance not only for the future healthy function of the organ, but also for the safety of the patient's life. This is eminently true when, as is often the case in scarlet fever, the morbid secreting process is rapidly and constantly going on, and when destruction of essential parts of the organ of hearing may be completed in a very short time. In suitable cases, the incision of the membrane decidedly alleviates the pain, limits the evil effects of pressure upon the ossicular chain and the walls of the middle ear, and obviates such a loss of the substance of the

membrane as would take place if we waited for spontaneous rupture. It is of special value in those cases of purulent collections in the middle ear where the membrane is thickened and more unyielding in consequence of previous disease, and where, therefore, the process of spontaneous rupture is rendered more difficult. In such cases, timely incision of the membrane may prevent, we may reasonably suppose, the extension of the disease to the labyrinth or to the meninges. It is to be noted that occasionally pus may exist in the tympanum without the membrane showing inflammatory signs. It will always be safe, when severe pain exists in the ear, attended by recent and marked loss of hearing, to make an exploratory opening, even although neither inflammation nor bulging of the membrane should exist. On the other hand, we must not incise the membrane when it is simply acutely inflamed, in the *absence of localized yellowish bulging*. Incision in such a case may, especially in scrofulous, tuberculous, or debilitated persons, excite a prolonged and obstinate purulent discharge which might have been avoided if the membrane had been left alone.

TREATMENT OF THE SECOND STAGE—THE STAGE DURING WHICH THERE IS A DISCHARGE FROM THE EAR.

Treatment immediately after Rupture of the Membrane. When the membrane has been perforated, either spontaneously or artificially, effective means should be taken to evacuate as completely as possible the tympanic cavity. This is to be done both by syringing and by inflation. The following plan may be generally,

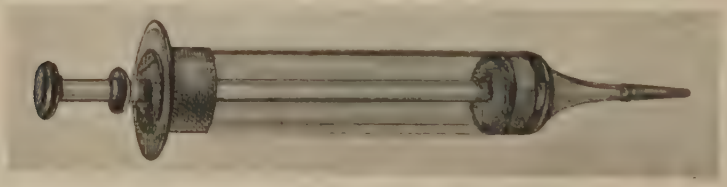

FIG. 170.—Glass ear syringe for use by patient.

in the first place, pursued. The ear should be syringed gently with boiled water or a warm 2 or 3 per cent. solution of boracic acid (see "Syringing the Ear," p. 67), then inflated by Politzer's method, or by Valsalva's method, if this be possible; the inflation will probably force secretion through the perforation into the external meatus (see "Inflation of the Middle Ear," p. 63). The canal of the ear should again be syringed, and then *dried with absorbent cotton wool*. Inflation not only assists in removing the secretion from

the middle ear, but it also tends to improve the hearing and counteract the formation of adhesions. In regard to syringing it is very important to instruct patients properly in the use of the syringe. Either a glass syringe (Fig. 179) with a proper flange for the fingers, or a ball syringe with, in the case of infants, a soft rubber ear-piece (Fig 180), should be employed. Careful instruction must also be given as to the proper method of drying the ear (see p. 5). Either a cotton-holder, or a thin metallic crochet needle, or a thin wooden match, may be used for fixing the cotton, a firm cylinder of which should project from the instrument for about an inch so as to avoid all danger of hurting the canal. If the patient is unable to force air through the perforation by Valsalva's method, he may have to be taught Politzer's. The frequency of the syringing will depend on the amount of discharge. If very copious, it should be done every three or four hours, and a cylinder of cotton should occupy the canal of the ear in the intervals to absorb the moisture. If the discharge be less copious, twice or even once daily may suffice. It is to be noted that *severe pain in the ear with throbbing may continue after the perforation.* In such cases, leeches, or hot and sedative instillations, as already described, may be required. Syringing with the hot antiseptic solution will also tend to relieve the pain. In favourable cases, the treatment just described will suffice to bring the discharge to an end, and heal the perforation in two or three weeks. But, if the discharge persist beyond that time, or even before that, the insufflation of *small* quantities of finely powdered boracic acid should be employed, after the syringing and drying (see p. 249). The treatment by syringing, inflation, and insufflation of boracic acid is probably more quickly successful in this stage of the disease than any other form of treatment.

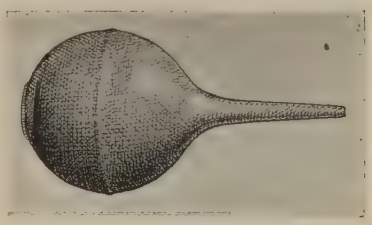

FIG. 180.—Ball ear syringe made of soft rubber.

Treatment of the Chronic Stage of the Discharge. When the discharge has gone on for several months we regard the condition as *chronic.* The treatment of this stage demands very careful and full consideration. We must not regard the closure of the perforation in the membrane as the main object. In many cases the perforation may rather be looked upon as a fistulous orifice, which it is desirable to keep open until the real seat of the disease—the mucous membrane of the middle ear—has been effectively treated. The chief difficulty in the way of successful treatment is due to the peculiarly complicated anatomical structure of the spaces forming the middle ear, rendering, in many cases, the thorough removal of

the secretion a very difficult task. In all varieties of this disease *cleansing* and *disinfection* of the cavities of the middle ear are of essential and primary importance.

Cleansing and Disinfection of the Ear. In order to obtain success it is essential to remove the inflammatory secretions, and to cleanse and disinfect the interior of the ear, as far as possible. Cleansing measures may be applied either through the external auditory canal, or through the Eustachian tube. By the external auditory canal we may employ ordinary syringing (see p. 67), intra-tympanic syringing (see p. 69), or simple drying.

Fig. 181.—Mode of syringing the ear.

Ordinary syringing through the external auditory canal is always necessary when the discharge is profuse (Fig. 181). It should be done twice a day, or, if the discharge be very copious, as frequently as four times. *Dry cleansing* by means of absorbent cotton on a cotton-holder (Fig. 182) is to be preferred to syringing, if the latter constantly produces disagreeable symptoms, such as pain or giddiness, or if the secretion be small in quantity, and not offensive to smell. In any case, after fluid injections, the moisture in the ear must be *thoroughly mopped up* and the parts dried with absorbent cotton.

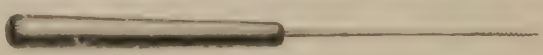

Fig. 182.—Cotton wool holder.

Solutions for Syringing the Ear. A selection may be made from the following: (1) Boiled water; (2) a solution of boracic acid in water (2 to 3 per cent.); (3) a solution of resorcin in water (2 to 3 per cent.); (4) a solution of carbolic acid in water (2 per cent.); (5) a solution of permanganate of potassium in water (Formula 99); (6) a solution of corrosive sublimate in water—1 in 3000; (7) a teaspoonful of a 10 per cent. alcoholic solution of salicylic acid to a wine-glassful of water; (8) peroxide of hydrogen (Formula 90). When the discharge consists in great part of stringy mucus (blennorrhœa), 4 or 5 drops of oil of turpentine added to 8 ounces of water are said by Politzer to have a useful effect.

For cleansing by the Eustachian tube the first and second solutions are most appropriate (for Syringing through the Eustachian Tube, see p. 70).

These solutions must all be used *warm*, say at a temperature of 102° Fahr.; and the syringe should first be heated by filling and emptying with water of the same temperature, otherwise the temperature may be too low. The efficiency of these cleansing measures is much aided by inflation of the middle ear, especially by Politzer's method, which is of great value in forcing out secretion from the middle ear to the external auditory canal, more particularly when the perforation is small. In a certain proportion of cases, especially in the earlier stages, simple cleansing and disinfection, carried out in a thorough and effective manner as described, are sufficient to remove the disease and heal the perforation. In most cases, however, it is necessary, in addition, to act upon the diseased mucous membrane of the middle ear with various kinds of *medicated agents*. The first in value is undoubtedly the group of antiseptics, and especially powdered boracic acid.

Boracic Acid Treatment. In boracic acid, employed as a fine powder, we have probably one of the most valuable remedial agents which have been put into the hands of the aural surgeon in recent years.

As a remedy for purulent disease of the middle ear, this substance was first introduced by Dr. Friedrich Bezold of Munich, in a paper entitled "Für antiseptischen Behandlung der Mittelohreiterungen," which appeared in the *Archiv für Ohrenheilkunde* of 13th June, 1879. While it was at first employed by Bezold on purely antiseptic principles, he does not maintain that its beneficial effects in chronic purulent disease of the middle ear are due solely to its antiseptic properties. Indeed, the anatomical peculiarities of the middle ear do not admit of thorough antisepsis being carried out. Considering that in solution boracic acid is not so valuable as in the form of powder, it is probable that a not inconsiderable part of the good effect is due to its being a very fine, generally non-irritating, powder. It is now admitted by all that a constantly moist condition of the interior of the ear is very unfavourable to recovery from the purulent process, and that a fine bland powder by absorbing moisture and so keeping the parts dry is, apart from any antiseptic property, a beneficial application.

The powder should be extremely fine, and should be blown into

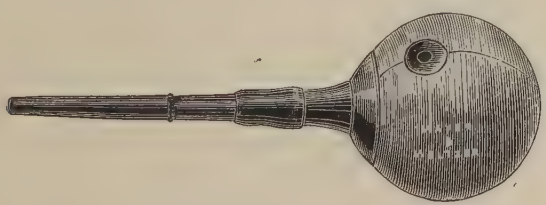

Fig. 183.—Ball insufflator for ear.

the ear by means of a tube. A portion of a quill or a glass tube forms a cheap and convenient instrument. A small quantity of the

powder is placed in the tube, and blown into the external auditory canal, while a piece of india-rubber tubing attached to one end of the quill will enable the patient to insufflate the powder into his own ear. A ball insufflator (Fig. 183), however, or a tube insufflator (Fig. 184), is on the whole the best instrument. In order to increase the antiseptic effect of the powder, Politzer adds, in cases having a peculiarly strong fetid discharge, 1 grain of carbolic acid to 15 grains of boracic acid, while in the blennorrhœal forms he adds 3 to 4 drops of oil of turpentine to 15 grains of the boracic acid. The author has found the addition of calendula (Formula 41) to be an advantage.

Fig. 184.—Tube insufflator for ear.

Mode of Using Boracic Acid. (1) The purulent secretion is removed by syringing with one or other of the solutions already mentioned, especially the solution of boracic acid or resorcin or carbolic acid. If ordinary syringing is insufficient to ensure thorough cleansing of the middle ear, one or other of the methods already described (see p. 67) of washing out the middle ear must be employed. (2) The moisture in the interior of the ear is then thoroughly removed, and the parts dried by means of absorbent cotton wool. (3) The middle ear is next inflated by Politzer's method, and, if more secretion is thereby forced out of the perforation, drying with absorbent cotton wool is again employed. (4) The fine powder is then insufflated into the canal of the ear so as to fill the inner half of the canal, while the outer half is to be occupied by a plug of salicylic or carbolized cotton wool. It is to be carefully noted, however, that if the perforation be very small, such as is frequently the case in the acute or early stage, only a *very small quantity* of the powder should be insufflated, just sufficient to form a fine dust upon the membrane and osseous walls of the meatus. In some cases, especially when the secretion is small in quantity and blennorrhœal in character, or when syringing produces disturbing symptoms, it is better to avoid the syringing altogether, simply wiping away the moisture with cotton wool, and insufflating the powder, or applying to the parts a pellet of dry cotton wool covered with boracic acid.

When the treatment is entrusted to the patient at home, thorough instructions should be given previously by the surgeon, who should make sure that the patient is able to blow the powder into the inner end of the canal. If too wide a tube be employed, in the case of a child, or of a person with a narrow external

meatus, the powder is very likely to reach no further than the outer part of the canal of the ear. On the other hand, firm packing of the ear with the powder is to be avoided. A case has come under the writer's notice, in which severe pain, giddiness, and fainting were excited by packing the ear very firmly with the powder.

After the powder has been employed in the manner just described, the ear should not be disturbed until the powder has become soft or moist, when the same process of syringing, drying, inflating, and insufflating, should be repeated. In some cases of profuse discharge the application may have to be made twice a day, in others once a day. When this mode of treatment answers well, the powder will soon be found to remain dry for two or three days, and by and by for weeks. When it is finally syringed out, the interior of the ear must be well dried. In a few cases, three or four applications of this treatment are sufficient to put an end permanently to the secreting process; in many cases, however, the continuance of the treatment for a considerable time is needed before permanent cessation of the secreting process is achieved. If granulations or polypi exist, these must necessarily be dealt with before the boracic acid treatment will prove effectual. It is important to remember that sometimes boracic acid *excites a copious watery discharge* after being insufflated. In such cases we should discontinue its use, and try some other form of treatment.

Treatment by Rectified Spirit. Probably next in value to boracic acid, as a method of treatment, comes rectified spirit, introduced by Löwenberg and Weber-Liel. It is most useful in cases associated with granulation tissue, and probably acts by virtue of its power of absorbing water and removing serous infiltration. After its application the mucous membrane, previously red and swollen, is seen to be paler.

The ear is first cleansed, dried, and inflated as already described. If the perforation be large, 15 drops of the warmed solution are poured into the ear, while the head is inclined to the opposite side, the drops being allowed to remain in the ear for ten minutes. The solution is then allowed to flow out, the inside of the ear is dried, and a plug of antiseptic cotton introduced into the meatus. This is repeated twice daily, or oftener if the discharge be very copious.

If the aperture in the membrane be small, there are several methods by which the fluid, lying in the external auditory canal, may reach, and act upon, the middle ear. The simplest method is to press the tragus frequently and firmly inwards upon the fluid in the external meatus; if the head is at the same time tilted back the fluid also enters the back part of the middle ear. For the same

purpose inflation of the middle ear, either by Politzer's or by Valsalva's method, is very useful; air is thereby forced through the perforation and through the fluid in the canal, giving rise to visible bubbles followed by a subsidence of the fluid in the canal, which sinks through the perforation into the middle ear. Swallowing with the nostrils closed also tends to suck the fluid into the middle ear. When by one or other of these methods the fluid passes into the middle ear, the patient may, if the Eustachian tube be permeable, feel it in his nose or throat. It is well at first to dilute the spirit with an equal quantity of water or, in some cases, with twice its bulk of water, till we ascertain how it is tolerated. While the first contact of the spirit often produces a momentary "nip," it is usually tolerated very well. The effect of the spirit may be enhanced in some cases by the addition of 3 per cent. of boracic acid or resorcin, and, if the discharge be persistently offensive, the addition of 2 per cent. of carbolic acid is beneficial. This mode of treatment may be continued for several months, and can be carried out very conveniently by the patient at home.

Iodoform in powder or solution is frequently employed. There is reason to believe that iodoform is especially useful in the tubercular form of purulent disease of the ear, and it may succeed where boracic acid has failed. The powder is applied in the same way as that of boracic acid (see p. 250), and it is sometimes judicious to dilute it with boracic acid—1 of the former to 4 of the latter. Iodoform, being a less soluble substance than boracic acid, is apt to collect in the ear, if it is not carefully removed by syringing, hence the surgeon should see the patient pretty frequently while the treatment is going on so as to make sure that the iodoform is not being deposited as a solid substance. Its use is safer when there is considerable destruction of the tympanic membrane. Certain persons cannot tolerate iodoform in any quantity owing to its *producing a violent eczematous inflammation* of the external meatus and the neighbourhood of the ear. The author has occasionally had to discontinue its use owing to this effect, sometimes produced even by a minute quantity. He sometimes employs it mixed with rectified spirit (Formula 82). Only a portion of the iodoform is dissolved by the spirit, the rest remaining in suspension, and thus the thorough shaking of the mixture is necessary before its use. The mode of application is the same as that of the spirit treatment.

Caustic Applications are often conjoined with the preceding methods of treatment. When we have to deal with granulation tissue, remnants of polypi, or hypertrophied mucous membrane, cauterization may be of great importance. The application of the solid nitrate of silver, a strong solution of perchloride of iron, chromic acid, or the

galvanic cautery may be essential to the success of the boracic acid or other antiseptic mode of treatment. The methods of applying these are described under the treatment of polypi (see p. 264). Nitrate of silver, fused on the point of a probe, may suit very well. Chromic acid is more efficient; but it must be applied carefully to the diseased tissue, fused on the point of a probe; or the point of a silver or platinum probe is dipped in chromic acid to which a small quantity of water has been added to remove its crystalline form. Politzer prefers a strong solution of perchloride of iron. It is scarcely necessary to add that, when applying these substances, the mirror and speculum must be used so that the eye may guide the hand. The galvanic cautery (Figs. 185 and 186) should be limited to hypertrophied

FIG. 185.—Handle of galvano-cautery for ear.

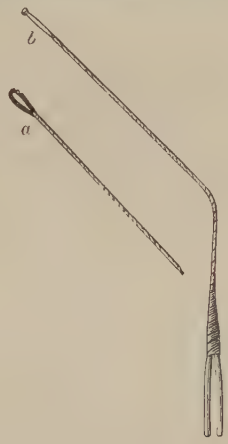

FIG. 186.—Burners for ear.

tissue or fibrous polypi, and it should be applied only by practitioners of considerable experience in aural manipulations (see p. 80).

Nitrate of Silver in a strong solution may be very useful, particularly when there is extensive destruction of the tympanic membrane, with much swelling of the mucous membrane. The strength of the solution should be 40 grs. to the oz. of water, and it is best applied by means of cotton wool on a cotton-holder with the aid of a mirror and speculum. Pain is rarely excited—only a slight warmth is produced in the ear. The more thoroughly the mucous membrane intended to be treated is freed from all moisture, the better will be the therapeutic effect of the nitrate of silver. The mucous membrane is whitened by the solution; and a fresh application should not be made until this white layer has been thrown off, which will probably occur in three or four days. If no distinct benefit is observed after six or eight applications the solution must give way to some other remedy. The writer has

found boracic acid, although ineffectual for a time, become completely efficacious after a few applications of the caustic solution.

Treatment by Astringents. Until the introduction of antiseptic remedies, astringents and caustics were the trusted means employed by aural surgeons in purulent middle ear disease. They are now much less frequently adopted, being in great measure supplanted by boracic acid and spirit. There are cases, however, although comparatively few, in which astringents do good after boracic acid and spirit have failed. They should not be employed during an acute exacerbation of the inflammation, when they tend to irritate, increasing the pain and inflammation. One of the best and most useful astringents is sulphate of zinc; the addition of carbolic acid probably adds to its usefulness (Formula 78). A solution of alum has the disadvantage of frequently exciting boils in the meatus. Solutions of acetate of lead and perchloride of iron are sometimes employed; but their tendency to form depositions on inflamed or abraded surfaces makes them objectionable. Finely powdered alum was formerly a favourite remedy, especially in cases associated with granulation tissue. With the purulent secretion, however, it forms a mixture which adheres very firmly to the tissue, while it tends, unless very carefully applied, to irritate the skin of the external meatus. Owing to these disadvantages and the introduction of other remedies, alum is now but rarely used. The insufflation of tannin is recommended by some specialists, and may be tried when other remedies do not prove satisfactory.

The Relative Value of these Remedies. Of these various local applications for purulent disease of the middle ear, we cannot, in a given case, predict with certainty which will prove most successful. The size of the perforation, the presence or absence of granulations, and the actual source of the secretion, have all to be taken into account in the selection of the remedy. The boracic acid treatment is the most generally successful, and we should therefore, in many cases, begin with this. But one remedy after another has sometimes to be tried, until we come upon the best one, and what is found to be an ineffective remedy at one stage of the disease may be very successful at another stage of the same case. The boracic acid, the alcohol, and the fluid astringents may be continued for a great length of time, after the patient thoroughly understands how to apply them. The caustic treatment, on the other hand, as well as that by intra-tympanic injections, can be employed only by the surgeon. When we entrust the carrying out of the treatment to the patient or his friends, it is desirable to see the case at least every two or three weeks in order to judge whether a change or modification of treatment may be required. The proper manner of using these remedies is of great importance. The surgeon should not only give precise directions to the patient or friends, but he should also once or twice cause the treatment to be carried out in its details in his own presence. Unsatisfactory results are very frequently due to the inefficient way in which the treatment is employed. In view of the possible consequences

of the disease, the patient should be urged to continue the treatment, even for many months if necessary, so as, if possible, to put an end to the purulent process. In *a large majority* of cases this will be achieved by perseverance and by a proper selection and variation of remedies. It is desirable that, some time after apparent recovery, the surgeon should examine the ear to make sure that the recovery is real, as patients are very ready to think that the disease is cured if no discharge appears externally; we know, however, that even then the purulent process may still exist. Crusts or desquamative collections often form after the discharge has ceased, and these should be removed.

TREATMENT OF CASES PRESENTING CERTAIN PECULIARITIES OR COMPLICATIONS.

Small Perforation and Thick Secretion. The purulent secretion may be very thick, while the perforation in the membrane is small. The cleansing operations are thus often prevented by the extreme smallness of the aperture in the membrane, hindering as it does the complete expulsion of secretion, or the admission of the cleansing fluid. In such a case enlargement of the perforation with a blunt-pointed paracentesis knife is likely to exercise a good effect upon the course of the disease. If the membrane should present a bulging, as if from accumulated secretion, at a place separate from the existing perforation, a second aperture made into the bulging part may have a beneficial influence (see "Incision of the Tympanic Membrane," p. 74).

Nipple-shaped Perforation. When the perforation is on the summit of a nipple-shaped projection, the case often proves peculiarly obstinate to ordinary treatment. For this condition the injection several times of warm water into the middle ear through the Eustachian catheter is recommended. Enlargement of the perforation may also be indicated. By the addition of these to the ordinary methods of treatment, the secreting process will eventually be brought to an end.

Granulations or Polypi may spring up very rapidly and lead to prolongation of the disease. Their removal with forceps or Wilde's snare (see p. 89), followed by the spirit treatment, will favourably change the course of the disease, unless they are based upon caries or necrosis. Before removing granulation tissue or polypi by means of an instrument, it is a wise precaution to employ, for a few days, antiseptic treatment to the interior of the ear, in order to diminish the danger of septic absorption by the freshly-cut surfaces. To this mode of absorption have been attributed some cases of fatal complications.

Perforation in the Membrana Flaccida. When the source of the discharge is mainly in the *attic* or *attic and antrum*, with perforation of

the membrana flaccida, the course of the disease is usually remarkably obstinate, and the special forms of treatment indicated are described at p. 282.

Stenosis of the External Meatus or Eustachian Tube may offer considerable difficulty in the treatment of purulent disease. The special modifications of treatment required in stenosis of the external meatus have been already described at p. 178. When the disease is associated with stenosis of the Eustachian tube, and the benefits of inflation cannot be obtained, suction by means of Siegle's pneumatic speculum, fitted air-tight into the external auditory canal, is useful in drawing out the secretion from the middle ear, especially when the perforation is small. Suction is at the same time useful in separating adhesions or preventing their formation. The pus, which exudes from the perforation during suction, is to be wiped away, and suction again applied until secretion no longer appears.

Caries or Necrosis gives a most unfavourable character to the disease. The treatment of this complication, however, is taken up under the Consequences of Purulent Inflammation, at p. 280.

External Applications, such as vesicants or stimulants, are frequently used behind the ear by practitioners. These applications are sometimes injurious, and, in the absence of proper treatment to the interior of the ear, quite useless. The practice of using them without any attention to the seat of the suppuration, without even any attempt to clean away the decomposing pus which fills the ear, is utterly bad. Only in syphilitic or markedly scrofulous persons are applications of iodine preparations behind the ear likely to do any good, and always merely as *auxiliary* to the careful treatment of the *interior of the ear*.

TREATMENT OF THE THIRD STAGE AFTER THE DISCHARGE HAS COME TO AN END.

The cure of the purulent process is generally attended by improvement, sometimes very considerable, in the hearing power. When the hearing still remains defective, after the active secreting process has ceased, there are certain modes of treatment, designed to improve the hearing, which should be tried. These are: (1) Inflation of the middle ear and rarefaction of the air in the external auditory canal; (2) certain operative measures; and (3) the use of the so-called artificial tympanic membrane or "drum."

1. **Inflation of the Middle Ear** and rarefaction of the air in the external auditory canal may prove useful, especially in cases which have completely cicatrized, by separating soft adhesions and improving the tension of the ossicular chain. When a dry perforation exists, inflation should be performed while the canal of the ear is plugged up, in order to augment the effect of the air pressure. These methods are more likely to be successful when employed immediately after

the cessation of the suppurative process; but they should not be continued too long. (See Treatment of Non-Exudative Inflammation of the Middle Ear.)

2. **Operative Treatment of the Defective Hearing.** When the defect of hearing is very great, and when no improvement is effected by other methods, incision of the adherent or thickened tissue may be followed by benefit. A certain degree of mobility, as tested by suction, must exist before such measures are employed, and no attempt of this kind should be made, unless the state of the osseous conduction of sound shows that the nervous apparatus of hearing is good. Attempts are sometimes made to secure cicatricial closure of old dry perforations by cauterizing the edges with solid nitrate of silver. Such attempts may excite a return of the purulent disease, and lead to further injury to the organ, while efforts of this kind rarely succeed in closing the perforation. Complete closure of the perforation, it is to be remembered, may be attended by *increase of the deafness.* Hence cicatrices are sometimes opened up again by cutting or the galvanic cautery, with the intention of improving the hearing power; but this is usually unsatisfactory, as fresh cicatricial tissue forms, with, it may be, aggravation of the deafness. Repeated incisions into a cicatrix occasionally prove useful in the case of atrophied parts of the membrane. In the various forms of adhesions between the tympanic membrane and the inner wall of the tympanum, or between the membrane and the incus and stapes, attempts with sharp instruments to separate the adhering parts are unsafe and ineffective; but, as Politzer has suggested, incisions made through the membrane close to the adhesions, followed by inflation, are not unfrequently advantageous to the hearing. When, for example, the membrane is adherent to the promontory, simple incision around the adherent part may prove beneficial; and, when it is adherent to the articulation of the incus with the stapes, a horizontal incision below the adhesion, by lessening the tension, may improve the hearing. When bands connect and bind the handle of the malleus to the inner wall of the tympanum or to the long process of the incus, their division with the knife may help to set free the ossicular chain. When, however, the manubrium is bound to the inner wall of the tympanum by direct adhesion, we must not endeavour to separate them by insinuating a knife between, but content ourselves with repeated incisions in the membrane, in the neighbourhood of the manubrium. Incision into the tense posterior fold of the membrane may help to set free the indrawn manubrium. So, also, a perpendicular incision behind the manubrium into the thickened and stiff membrane may relieve the tightness and improve the hearing. When the recess leading into the fenestra ovalis is exposed to view, and

the stapes appears to be unduly drawn backwards and inwards by a shortening of the tendon of the stapedius, the division of this tendon has been recommended; and, when it is cicatricially shortened, such a division may be useful. The propriety of these operative measures, which are sometimes carried out with the object of improving the hearing after chronic purulent disease of the middle ear has run its course or has been cured by treatment, can only be judged of, and the manipulations should only be undertaken, by an experienced aural surgeon.

3. **The Artificial Drum.** The method of improving the hearing after a chronic purulent process has come to an end, or even before it has totally ceased, by the use of the *artificial tympanic membrane*, has been fully described in the chapter on Methods of Treatment (see p. 85).

The Nasal and Pharyngeal Mucous Membrane should, in all stages of the disease, be examined, and, if any morbid condition be found to exist, such as *adenoid vegetations* or *chronic rhinitis*, it must be properly treated (see Chapter VI.).

General Constitutional Treatment is often required, especially when the disease occurs in persons of a scrofulous, anæmic, syphilitic, or tubercular constitution (see General Remedies in list of Formulæ). The student is also referred to "Hygienic Treatment," p. 103.

In cases where a permanent perforation is left behind, a plug of cotton wool should be kept in the orifice of the ear during cold, windy, or wet weather, while water should be carefully excluded from the interior of the ear.

CHAPTER XII.

CONSEQUENCES OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

This chapter will be taken up with the consideration of those consequences of purulent inflammation which are *limited to the ear itself, including the Fallopian canal.* These will be described in the following order:

I. Aural Polypi.
II. Affections of the Mastoid Process.
    (1) Acute mastoid periostitis.
    (2) Acute purulent collections in the mastoid cells.
    (3) Chronic processes (resulting from purulent disease) in the mastoid cells, antrum, and attic.
III. Facial Paralysis.

The following chapter will be devoted to those consequences which extend beyond the ear into the intra-cranial and vascular spaces.

I. AURAL POLYPI.

With extremely few exceptions, polypus of the ear is the result of an antecedent purulent process in that part of the ear from which the growth springs. And since in the great majority of cases these growths spring from the mucous membrane of the middle ear, and are the result of purulent inflammation of the middle ear, it is convenient to describe them under the heading of the consequences of that disease.

Varieties of Polypi. Three forms of polypus are met with in the ear. These have been named by Steudener, from their histological characters: (1) Mucous polypi; (2) Fibrous polypi; and (3) Gelatinous polypi or myxomata. The mucous variety is by far the most frequent, the gelatinous is extremely rare.

Mucous Polypi. These are red, soft, globular, or, if large, club-shaped masses, which are apt to bleed, from even gentle touching. Their surfaces are frequently beset with small, red, granular projections, resembling the surface of a raspberry. When they are so large as to fill the tympanum and the whole of the external auditory canal, the surfaces, which press upon the surrounding walls of the

external auditory canal, are usually rendered smooth. Their attachment to the mucous membrane is frequently pedunculated, but they are also found, not uncommonly, to have a broad or sessile base. Sometimes the stem divides into two branches, each supporting a polypus, or one polypus may have two or more pedicles. Probably in as many as nine out of every ten cases aural polypi have their roots in some part of the mucous lining of the tympanic cavity, and the growth is seen through a perforation in the tympanic membrane, or, if large enough, it extends into the canal of the ear, even so far as to project at its orifice (Fig. 187). They spring most frequently from the posterior or inner wall of the tympanum, but they may also come from the inner surface of the membrane near the edge of a perforation. The growths are often associated with a very thickened condition of the mucous membrane of the tympanic cavity, called by Wendt polypoid hypertrophy of the mucous membrane. They are occasionally attached to some part of the ossicular chain. They more rarely grow from the tympanic opening of the Eustachian tube, and have in some cases their origin in the attic, antrum, or mastoid cells, from which they may project into the tympanic cavity, or protrude through a carious opening in the posterior osseous wall of the external auditory canal. In comparatively rare cases they grow from the outer surface of the tympanic membrane, and cases occur in which they seem to consist of the tissue of the membrane itself—polypoid degeneration of the membrane. Polypi are found least frequently to have their base in the external auditory canal, when they are usually the consequence of otitis externa, acute or chronic, and are found in the osseous part of the canal.

The Size of Mucous Polypi presents great varieties, from that of a hempseed or pin-head, so small as to be scarcely distinguishable in the secretions of the

FIG. 187.—Large mucous polypus, which dilated the external auditory canal, and protruded from the orifice of the ear—A, pedicle; B, head.

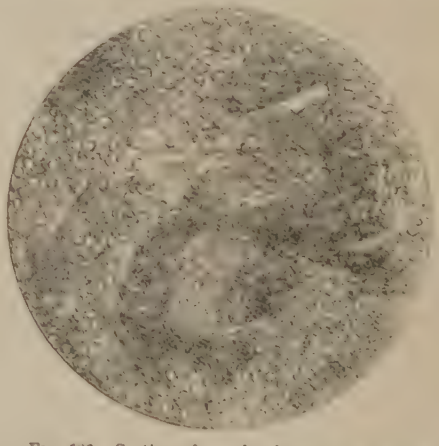

FIG. 188.—Section of aural polypus. Central portion (300 diam.). Mucous areolar tissue, containing granular cells and nuclei of cells.

tympanum, to one which fills the tympanum and external meatus, projecting, fungus-like, from the external opening of the ear (Fig. 190).

Structure of Mucous Polypi. Mucous polypi (Figs. 188 and 189) are usually hyperplastic growths of mucous membrane, and consist, microscopically, of numerous round cells, connective-tissue fibres, glands, cystic spaces, and blood-

vessels. The surface has often a papillary structure, or contains many gland-like depressions, and stratified epithelium covers it. On the deeper part of the growth, near the root, the epithelium is sometimes columnar and ciliated. When the polypus protrudes from the outer orifice of the ear, the part which projects externally is sometimes covered by a fine cutis. Several polypi may exist in one ear, while it is not uncommon to find them in both ears.

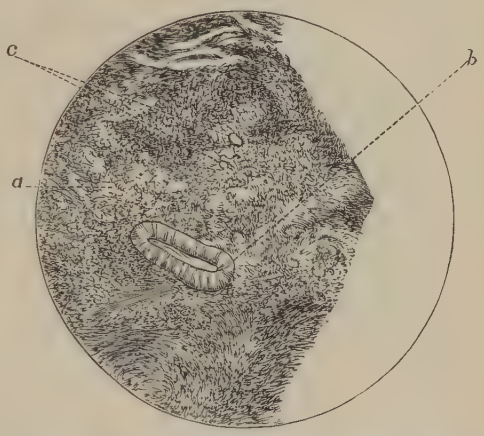

FIG. 189.—Section of aural polypus. General view of portion near surface (40 diam.), showing—*a*, Mucous areolar basement tissue, with granular cells and nuclei; *b*, gland-like follicle, lined by epithelium, chiefly cylindrical; *c*, small blood-vessels.

Fibrous Polypi are much less frequently met with. They are paler and smoother than the mucous variety. They contain no cysts and comparatively few vessels. The tissue consists of a pretty dense fibrous stroma with spindle cells, and they are covered with stratified epithelium. The true fibrous polypus seems generally to arise from the periosteum of the external canal or of the tympanum.

The **Myxomatous Variety** is extremely rare, and consists of a gelatinous mucous tissue.

Causes of Aural Polypi. It has been already stated that a polypus in the ear is, in the great majority of cases, the result of purulent inflammation of the middle ear. The irritating effects produced by the constant saturation of the parts with pus undoubtedly contribute very materially to their formation. The growths, on the other hand, aggravate the discharge by maintaining the inflammation of the middle ear—the original disease. It is probable that persons of scrofulous constitution, who suffer from purulent disease of the ear, have greater liability to the formation of polypi.

While polypi are *generally* secondary to a purulent process, there are authentic cases, though rare, of the polypus being the primary disease, giving rise secondarily to inflammation, suppuration, and perforation of the membrane.

Polypi are found more frequently in males than in females, and more frequently in children than in adults.

Symptoms of Aural Polypi. If the polypus is small, the *subjective symptoms* are pretty much the same as in simple purulent disease of the middle ear. When they cause obstruction and pressure, there may be great pain excited in the ear and head, as well as severe tinnitus and giddiness.

If large, the red mass is seen in the external auditory canal, or even protruding from the outer orifice (Fig. 190). If it is small, the purulent secretion requires to be removed and the parts dried, when we generally see the small red mass in the tympanic cavity. If very small, and situated in some corner of the tympanic cavity, the growth may be difficult to recognize. It is generally necessary to use the probe (Fig. 191) in order to make quite sure of its existence. In using the probe, great caution should be exercised, and the interior of the ear must be thoroughly illuminated, so that the eye may guide the hand. With the probe we are able to move the growth, and thus distinguish it from simple hypertrophied tissue or the swollen mucous membrane of the inner wall of the tympanum. By moving the point of the probe cautiously round the growth we are also frequently able to determine its attachment, although in some cases the exact point of attachment of a polypus cannot be ascertained until after the treatment has been carried on for a time. Associated with a polypus there is generally considerable destruction of the tympanic membrane; there may, however, be a very large polypus and a very small perforation. In this case, after the polypus has grown through the perforation out of the tympanic cavity, the aperture in the membrane becomes less in size, so that its edges constrict the growth, which, continuing to increase, at length covers the outer surface of the membrane like a mushroom. In examining such a case we are liable to be deceived, and to conclude that the membrane is totally gone. On removing the accessible part of the growth, however, it is found that the membrane is intact with the exception of a small perforation.

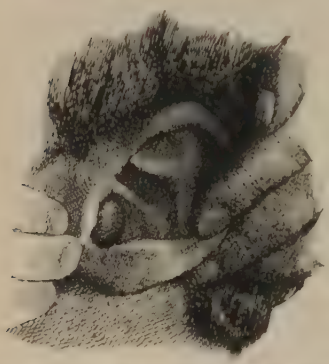

Fig. 190.—Polypus protruding from external meatus.

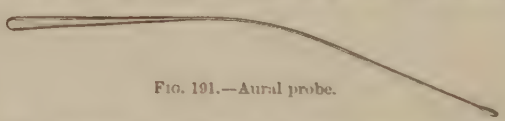

Fig. 191.—Aural probe.

The discharge from the ear, where polypi exist, is frequently slightly tinged with blood.

Course and Consequences. Such growths sometimes form very rapidly, and have been known to attain the size of a bean in a week or two. Von Tröltsch relates a case, in which a polypus, so large as to project from the outer orifice of the ear, formed in six weeks. Their growth is, however, usually more slow, and after they have

reached a certain size they frequently become stationary. It is observed that the imperfect removal or treatment of a polypus may have the effect of stimulating it to greater and more rapid growth. A polypus occasionally *separates spontaneously*, and comes away during syringing; in such cases the pedicle has been thin and the head of the growth large.

While a polypus in the ear may exist for many years without producing much mischief, it may, on the other hand, lead to serious results by obstructing the passage outwards of purulent secretion. In this way there may be brought about retention with caseous change of the purulent secretion, caries or necrosis, or extension of the purulent inflammation to the interior of the cranium or to the large vessels. Calcification or even ossification of a part of the growth has been observed.

Diagnosis and Prognosis. The occasional appearance of blood in a purulent discharge from the ear should excite suspicion of the presence of a polypoid growth. The objective examination, with the use of the probe, places the question beyond doubt.

In most cases, if unassociated with caries or necrosis, complete and permanent removal is effected by proper treatment. For the prognosis of the purulent disease associated with these growths, see p. 239.

Treatment of Aural Polypi. This includes (1) the removal of the growth; (2) the destruction of its root in order to ensure complete eradication; and (3) the removal of the cause.

Fig. 192.—Wilde's snare for removing aural polypi.

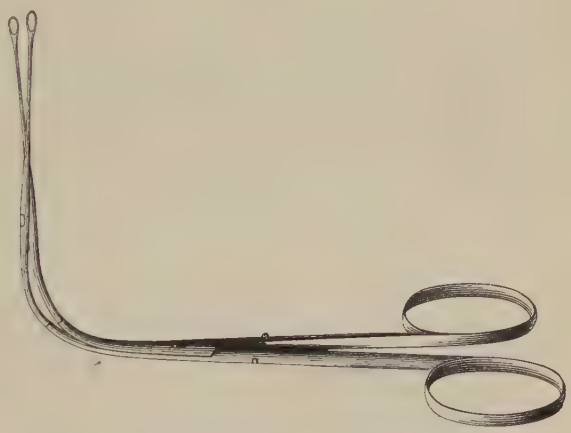

Fig. 193.—Forceps for removing small polypi.

1. **The Removal of these Growths** may be brought about by operative measures, by the application of caustic substances, or by the spirit treatment. The most efficient operative measure is the use of

Wilde's snare (Fig. 192), as described in the chapter on Methods of Treatment at p. 89. In the removal of small soft polypi, or of the remains of larger ones, such forceps as those represented in Fig. 193 are very useful, and sometimes sufficient, if we be careful not to employ much traction. *Toynbee's lever ring forceps* (Fig. 194)

FIG. 194.—Toynbee's lever ring forceps.

are convenient for the removal of small polypi, especially where the canal of the ear is very narrow. Politzer employs a small ring knife (Fig. 46*c*) for removing small polypi or granulation tissue from the walls of the external auditory canal. The ring knife is pressed over the growth, which is then quickly sliced off.

2. **The Destruction of the Root** is to be effected by means of caustic substances, or by the use of rectified spirit. Before the application of a caustic substance to the root of a polypus, the latter must be carefully dried with absorbent cotton wool.

The Chemical Caustics most frequently used for destroying the roots of polypi are chromic acid, chloro-acetic acid, solid nitrate of silver, and perchloride of iron. The favourite one with the author is chromic acid, applied in the form of crystals, or of a very concentrated solution on the point of a silver probe, which must be carefully washed immediately afterwards. We must avoid touching the neighbouring tissue. If severe pain be excited, a syringeful of warm water will at once relieve it. The chromic acid may require to be applied three or four times, at intervals of three days, before the base of the polypus is destroyed. Solid nitrate of silver has a less intense, because a more superficial, effect than either of these two acids, and it sometimes occasions very considerable pain, which may continue for several hours. The most convenient method of applying the solid nitrate of silver is by fusing a portion on the roughened end of a probe made of steel, platinum, or aluminium. The point of the probe is first held in a flame till it is almost red-hot, and then gently pressed upon a piece of solid nitrate of silver, when a portion of the latter is fused, and, on cooling, the caustic forms a thin layer adhering to the point of the probe. The same method is applicable with chromic acid. Nitrate of silver is now rarely applied to the roots of polypi. Politzer speaks highly of the efficacy of perchloride of iron for destroying the roots of polypi or granulation tissue. He applies the crystal or a strong solution on the point of a probe or cylinder of cotton wool. A small dark crust is formed, separation of which, either spontane-

ously or with the help of a probe, should be followed by a fresh application of the substance. The use of the iron must be continued until complete destruction of the morbid tissue is effected.

When the morbid tissue is soft and cellular, these applications are usually quickly effectual in bringing about its disappearance. On the other hand, when it is dense and fibrous in character, their most prolonged use may end in failure. In these cases, which are comparatively few in number, no caustic is so effective and advantageous as the galvanic cautery applied in the manner described at p. 80.

Spirit Treatment. The author has found, however, that in many cases, after the removal of the polypi so far as is possible by means of instruments, the continued use of the spirit treatment as described at p. 251 will suffice, without the application of caustic substances, to bring about a satisfactory result. Where operative treatment is rendered difficult, as in young children, or when the external auditory canal is very narrow, or when the patient resides at a distance from the surgeon, and cannot remain under his personal supervision for two or three weeks, the treatment of even larger polypi by rectified spirit should be tried, the patient having been carefully instructed in the thorough drying of the parts, and in the proper application of the remedy. As a mode of treating granulations or the roots of polypi this treatment is generally efficient.

3. **The Removal of the Cause** of the polypi is an essential part of treatment, if we aim at complete and permanent cure. Remedies must therefore be diligently employed for the *removal of the purulent disease* on which the growths depend. For details the reader is referred to the description of the treatment of the second stage of purulent inflammation of the middle ear (see p. 246).

II. AFFECTIONS OF THE MASTOID PROCESS, INCLUDING THE ANTRUM MASTOIDEUM AND ATTIC OF THE TYMPANUM.

Under this heading will be included: (1) Acute mastoid periostitis; (2) acute purulent formations in the mastoid cells; and (3) chronic purulent processes in the osseous framework and contents of the mastoid cells, antrum, and attic.

(1) *ACUTE PERIOSTITIS OVER THE MASTOID PROCESS.*

Syn.—Periostitis Mastoidea; Mastoid or Squamo-Mastoid Abscess.

Causes of Mastoid Periostitis. This disease has its origin, in the great majority of cases, in purulent inflammation of the middle ear. If primary in its origin, which is rarely the case, the inflamma-

tion may be due to an injury or to the influence of cold. The author has seen a severe form of the disease excited in a boy by a man laying hold of the boy's ears and lifting him by them from the ground; in another by a blow on the mastoid inflicted with a poker. It is also occasionally found as a complication of diffuse or circumscribed inflammation of the external meatus, the periosteal lining of which is directly continuous with that covering the mastoid region behind the auricle. Much more frequently, however, it is due to the extension of inflammatory disease, or the migration of pathogenic organisms, previously existing in the interior of the mastoid cells, to the periosteum covering the outer shell, either directly through the osseous tissue or by the connective tissue, vessels, etc., which penetrate the cortex. The gaps or fissures in the bone, often existing in childhood, especially the *squamo-mastoid fissure*, also facilitate the extension of inflammation from the interior to the exterior of the mastoid process. It is to be remembered, however, that, while the inflammatory conditions which affect the outer parts of the mastoid region have generally their seat chiefly in the periosteum, they are occasionally limited to the cutaneous and subcutaneous or glandular tissue over the mastoid process.

Symptoms of Mastoid Periostitis. The first symptom is usually pain in the mastoid region, frequently of a very intense character,

FIG. 195. Anterior view of auricle and side of head in squamo-mastoid periostitis of right side.

FIG. 196. Posterior view of auricle and side of head in squamo-mastoid periostitis of right side.

which shoots along the neighbouring parts of the head; the surface of the mastoid process is also extremely tender on pressure. The patient may be unable to sleep for nights together. The soft parts soon become red, swollen, and œdematous. The œdema may extend a considerable distance beyond the mastoid region. In consequence

of the swelling of the tissue behind the concha the auricle juts outwards, downwards, and forwards from the side of the head. This is strikingly seen when we look at the head from the front or from behind (Figs. 195 and 196), but it may escape notice if we look at the ear laterally. There is usually more or less feverish disturbance.

Course and Consequences. In some cases the inflammatory symptoms subside without suppuration; but generally in the course of from a few days to two weeks pus forms either between the periosteum and bone or outside the periosteum. When there is only a small quantity of matter, fluctuation may be absent; but, on the other hand, fluctuation may apparently exist, and yet no pus may be found on incision. The swelling is often most pronounced *above the auricle*, over the squamous portion, and large purulent formations may be found in the squamo-mastoid region. When these abscesses are incised a very considerable area of bone may be found denuded of periosteum, and yet there may be no caries or necrosis.

The spontaneous opening of the abscess is in many cases long delayed, perhaps for several weeks. The opening generally takes place behind the auricle; but it may occur in the external auditory canal either at the postero-superior wall of the osseous portion, or through the cartilaginous part of the canal. In this case, on pressing the bulging over the mastoid process, matter is seen to issue from the canal of the ear. If no complication arise in the bone recovery soon follows the complete emptying of the abscess.

But the periostitis may end in caries or necrosis of the outer shell of bone. If frequent relapses of the inflammation take place, there is reason to suspect caries or necrosis. The probe will, however, decide the question. It is to be remembered that a purulent collection over the mastoid is often simply the result of *the escape of pus from the mastoid cells* through a carious erosion in the cortex, or, in the young child, through the unclosed squamo-mastoid suture. In such cases simple incision of the abscess will not prove sufficient; free operation on the mastoid itself will be necessary (see p. 91).

Diagnosis and Prognosis. We must not confound with this disease the œdema, swelling, and even redness not unfrequently seen over the mastoid process in connection with acute inflammation of the external auditory canal or of the middle ear. The intensity of the pain and the greater redness and swelling of true periostitis are usually sufficient to distinguish this disease. It must also be remembered that swelling and tenderness of the *glands* over the mastoid process are frequently seen in purulent disease of the middle ear, and must not be mistaken for periostitis.

Periostitis of the mastoid process without implication of the bone usually terminates in complete recovery.

Treatment of Mastoid Periostitis. In the milder cases, attended by little pain, we should employ the tincture or ointment of iodine (Formulæ 63 and 23) over the mastoid region, and at the same time remove any obstruction to the escape of secretion from the middle ear which may be found to exist. Politzer recommends, as abortive treatment, the repeated injection of warm water into the middle ear by means of the Eustachian catheter (see p. 70). Warm poultices or fomentations applied over the inflamed mastoid region have generally a marked effect in relieving the pain. In Germany, however, the *use of cold* has for some years been practised in these and other acute inflammations of the ear, although it is not as generally adopted in this country. Cloths dipped in iced water applied over the mastoid region and frequently changed, or Leiter's cooling apparatus, six coils of the tube being placed behind the auricle and three in front, are suitable means of applying cold. In employing Leiter's apparatus a piece of lint should intervene between the skin and the metallic tubes. By this mode of treating mastoid inflammation at *an early stage* and when the symptoms are very acute, great relief is often obtained, the inflammation being not unfrequently cut short and suppuration prevented. If subsidence of the inflammatory symptoms does not quickly follow upon the foregoing treatment, *local blood-letting* over the mastoid region by means of leeches or Heurteloup's suction apparatus should be carried out (see p. 65).

Wilde's Incision. When no marked improvement takes place in two or three days, the symptoms being very acute, a free incision made through the swollen infiltrated tissues down to the bone tends to cut short the inflammatory process with its attendant symptoms, even before the stage of suppuration. This, on account of its having been first recommended by Wilde of Dublin, is usually known as *Wilde's incision*. A strong-bladed scalpel is used, and if there is distinct fluctuation at any part, that position should be chosen for the incision. But, if no fluctuation is found, the best position for the incision is parallel with the auricle and about a quarter of an inch distant from it. The cut should extend to from half an inch to an inch in length, and the tissues should be severed to the bone, which is sometimes *at a considerable depth*. Should the posterior auricular artery be cut, pressure or torsion will usually suffice to check the hæmorrhage. The ligature is rarely required. When the abscess is based upon a *chronic* purulent affection of the ear, we generally find a carious aperture in the cortex of the mastoid, and further operative measures will be required. In *acute* cases, however, there may be no caries, although the bone may be denuded of periosteum, and then *rapid cessation of the discharge* from the ear takes place, followed in a short time by a very satisfactory

result. After the incision, a drainage tube should be inserted in the opening, or it may simply be stuffed with iodoform gauze, in order to prevent premature closing of the wound and recurrence of the disease; antiseptic dressings are applied externally. If after a day or two the pain in the mastoid region is not relieved by the incision, we must not hesitate to *perforate the bone* (see p. 91).

Incision in External Meatus. More rarely the collection of pus takes place in the postero-superior wall of the osseous part of the external meatus. If there be marked swelling and pain in that situation, incision is indicated. If an opening already exists from which matter escapes when the bulging behind the auricle is pressed upon, an incision may be unnecessary, as by sustained pressure upon the abscess we may bring about complete evacuation and healing. If caries or necrosis should result, appropriate treatment (see p. 280) must be carried out.

Laxative and calmative medicines may be required, and complete rest is indispensable.

(2) *ACUTE PURULENT INFLAMMATION IN THE MASTOID CELLS.*

Syn.—Ostitis Mastoidea; Secondary Reactive Inflammation of the Mastoid Cells (Politzer); Acute Purulent Collection in the Mastoid Cells.

The purulent inflammatory affections of the middle ear, which have been already described, nearly always involve the mastoid cells to a greater or less extent, by continuity of mucous membrane. Indeed pus *generally* makes its way from the tympanic cavity into the antrum when the patient is lying on his back, but only in a certain proportion is this attended by inflammation in the mastoid cells or in their bony walls.

But, under the above heading, we have to describe an acute inflammation in the mastoid cells and their bony walls, which usually comes on in the course of the acute stage of purulent disease of the middle ear, is attended in most cases by rapid formation of pus in the cells, and is frequently limited to the vertical cells behind, below, and more superficial than, the antrum, between which and the mastoid cells *there may be no connection.* The muco-periosteal lining of the cells is at first red and swollen, and the osseous tissue shares in the inflammatory process. After a time the cells become filled with purulent or muco-purulent secretion; granulation tissue also forms in their interior with cario-necrosis of the osseous tissue.

Causes. During the discharging stage of acute purulent inflammation of the middle ear this disease may be excited (1) by obstruction to the exit of pus from the mastoid cells to the tym-

panum; (2) by irritating applications to the tympanum; (3) by forcible or injudicious syringing; (4) by the action of cold; (5) by an injury. In some cases there seems to be no direct continuity between the inflammation in the tympanum and that in the cells; probably the fresh septic centre is established behind by microbic migration from the tympanic cavity. In the author's experience, otitis media associated with *epidemic influenza* seems often to be followed by this complication.

Subjective Symptoms. In many cases the subjective symptoms are very severe. There is violent pain in the mastoid region, shooting down the neck and over the whole head, with great tenderness on pressure or percussion. There is frequently also a most painful *sense of fulness* in the mastoid process. The pain in some cases is very intense, affecting not only the mastoid area, but as far back as the occipital bone, into which the disease often undoubtedly extends. In severe cases there may be neither rest by day nor sleep by night. On the other hand, we find occasionally that *the pain is not severe* and may only be experienced on pressure, and we are then apt to overlook the true nature of the disease. There is usually marked feverishness of an intermittent kind, with, in some cases, rigors. Giddiness is occasionally a marked feature of the disease.

Objective Symptoms. There is usually *very profuse* discharge from the ear, syringing being quickly followed by fresh discharge; the walls of the osseous canal are *much swollen*, especially the superior and posterior. In many cases the soft parts over the mastoid process are unaltered, the impression conveyed both to the eye and the touch being that of *bulging of the bone*. This bulging is often most marked as far back as the junction of the mastoid with the occipital bone. The inflammatory disease may, however, extend through the cortex to the periosteum and superficial structures, when the aspect becomes very much that of mastoid periostitis. Then there are varying degrees of redness, hardness, and œdema, frequently extending from the mastoid process over a considerable part of the neighbourhood, especially in a backward direction.

Course and Consequences. While, in the slighter varieties, the inflammatory process may subside and pass away without suppuration, much more frequently a collection of pus forms, and after great suffering on the part of the patient makes its way either through the outer shell of bone behind the auricle, or, much less frequently, through the osseous wall of the canal, leaving a carious opening in either of these places. It rarely finds its way into the tympanic cavity, owing to the closure by swelling or otherwise of the aperture between the tympanum and the antrum. The collection of matter

may occupy a large part of the interior of the mastoid process, or it may be more limited. If it burst through the inner surface of the *lower part* of the mastoid process (digastric fossa), there is formed a deep-seated burrowing abscess under the muscles and fascia below the mastoid region. In children the rupture of the abscess through the outer shell of bone at the antero-superior part of the mastoid process is much more easy than in the adult. This is owing partly to the fact that the outer wall of the antrum mastoideum is much thinner in the child, but also to the presence in the child of a suture—the squamo-mastoid—in the outer wall. When a carious opening has thus formed in the outer shell of bone, the course is that described under the head of caries of the mastoid (see p. 280). Caries may also extensively involve the osseous septa between the cells in the interior, while large parts of the interior or of the cortex may be converted into sequestra by necrosis. But extension of the inflammation and suppuration or the formation of a carious opening or of a sequestrum may take place *towards the cranial cavity*, especially in the direction of the shell of bone separating the mastoid cells from the lateral sinus. In operating, the purulent collection may be found to extend to the sinus itself.

Diagnosis and Prognosis. When the superficial soft parts are involved in the inflammation, we can seldom distinguish this disease from mastoid periostitis, until after Wilde's incision has been made. When no change is perceptible in the tissues outside the bone, the symptoms being only of a subjective character, we can exclude the possibility of mastoid periostitis. If, in a case with profuse discharge from the ear, there is swelling of *the upper and back wall* of the osseous meatus and persistent pain on pressure over the mastoid, along with a more or less marked bulging of the bone, but without any, or with but slight change in the soft tissues, we are safe in diagnosing a purulent collection in the mastoid cells. The *prognosis* is very favourable if the condition be recognized and the mastoid operated upon. Otherwise the patient is placed in danger from extension to the sigmoid sinus or interior of the cranium. This danger is much increased when there is an insuperable impediment to the escape of matter from the tympanum, as by exostosis or closure of the external auditory canal. When great thickening or sclerosis of the external osseous shell exists, the prognosis is likewise unfavourable. The results of operation in acute cases are *much more speedily favourable* than in the chronic conditions.

Treatment of Acute Purulent Inflammation in the Mastoid Cells. In the early stage, when we may be in doubt as to whether it is simply mastoid periostitis or an acute purulent collection in the cellular spaces, the treatment for mastoid periostitis (p. 268) is

appropriate. When, however, it is evident that we have to deal with pus in the mastoid cells, we must not delay opening them, as this operation will usually be attended by the most satisfactory results. It is much safer, if in doubt, to *perforate the mastoid at once.* See Operations on the Mastoid, at p. 91.

(3) *CHRONIC PROCESSES IN THE OSSEOUS FRAMEWORK AND CONTENTS OF THE MASTOID CELLS, ANTRUM, AND ATTIC.*

Under the designation of chronic processes are included *caries and necrosis, hyperostosis, caseous and cholesteatomatous collections, sclerosis, dilatation of the antrum, contraction of the antrum and obliteration of the cellular spaces.*

Disease of the osseous framework of the middle ear is in nearly all cases the consequence of purulent inflammation of the mucous membrane—especially inflammation associated in its origin with scarlet fever or pronounced scrofula. Just as we find in other bones of the body that caries or necrosis is usually secondary to inflammation of the periosteum or soft parts over the bone, so in the temporal bone caries or necrosis is usually the result of inflammation either of the mucous membrane (the deeper layers of which perform the functions of periosteum) lining the middle ear, or of the periosteum covering the outer cortical part of the mastoid process. It is most common in childhood, and, when met with in adults, it is found in many cases to have originated in childhood. In early life it is not unfrequently based upon tubercular disease of the bone (see p. 55). Caries and necrosis often co-exist in the same person.

Sequestra. Considerable portions of the temporal bone are sometimes exfoliated in a necrosed state (Fig. 197). The annexed engraving (Fig. 198) shows the annulus tympanicus, with a

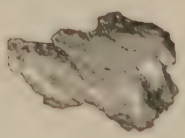

Fig. 197.—Sequestrum removed from mastoid process.

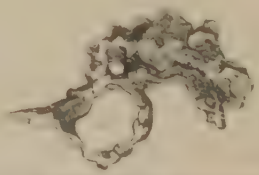

Fig. 198.—Sequestrum from a child.

portion of the mastoid process, exfoliated from a child, a patient of the author's, who suffered from purulent disease of the middle ear, originating in scarlet fever a year before. Cases are recorded by various writers of large portions of the temporal bone being exfoliated. Gruber relates one in which the whole of the mastoid process, with the groove for the lateral sinus on its inner surface,

was exfoliated. The cochlea, from its more intimate relation to the tympanum, is necrosed more frequently than either the vestibule or the semicircular canals. Toynbee, Wilde, Voltolini, and others relate instances in which the whole osseous labyrinth came away as a sequestrum. The author removed from a boy a sequestrum which included almost the whole of the osseous labyrinth (Figs. 199 and 200). Large fragments of necrosed bone are sometimes

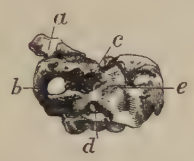

FIG. 199.— Outer aspect of sequestrum of osseous labyrinth. *a*, Superior semicircular canal; *b*, horizontal semicircular canal; *c*, opening of fenestra ovalis; *d*, opening of fenestra rotunda; *e*, the outer wall of the cochlea.

FIG. 200.—Inner aspect of sequestrum of osseous labyrinth. *a*, Superior semicircular canal; *b*, horizontal semicircular canal; *c*, cavity leading into the vestibule and scala vestibuli; *d*, aperture common to the superior and posterior semicircular canals

found in the interior of the temporal bone after death. It is to be noted that while a small carious aperture in the inner wall or in the roof of the tympanum may have a fatal issue, large portions of the osseous framework of the ear, in the form of sequestra, may be exfoliated without danger to life, although usually with serious injury to, or complete destruction of, the power of hearing.

FIG. 201.—Carious erosion of groove for lateral sinus, consequent upon suppurative disease of middle ear. A, Internal auditory canal; B, carious disease in situation of right lateral sinus.

Most frequent situations of Caries and Necrosis. Diseased bone is met with most frequently in the *mastoid region*, especially in the convex outer wall, and (although not so commonly) in that part of the mastoid forming the posterior wall of the osseous external

meatus. This frequency is no doubt due to the action of the micro-organisms in the stagnant decomposing pus which is so likely to collect and be retained in the antrum and other cavities in the mastoid part of the temporal bone. The inner or sigmoid wall of the antrum and neighbouring mastoid cells may be found perforated by caries in persons who have died from septic thrombosis of the sigmoid sinus (Fig. 201). On the *tympanic inner wall* there may be circumscribed carious spots or even apertures leading into the labyrinthine cavities (Fig. 202). The walls of the *facial canal*, above and behind the pelvis ovalis, may be eroded or destroyed, giving rise to facial paralysis (Fig. 202).

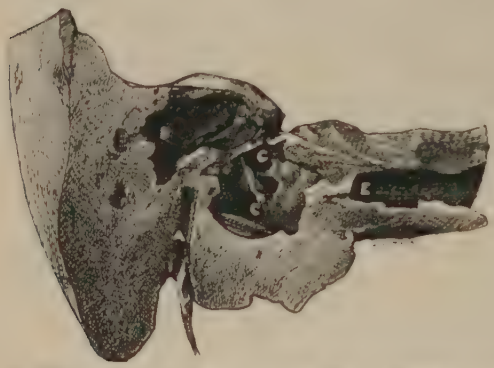

FIG. 202. Inner half of temporal bone, showing facial nerve denuded of its bony covering above and behind in the tympanic cavity. The nerve was embedded in granulation tissue. A, Lower part of facial nerve; B, antrum; C, carious apertures on inner tympanic wall; behind and above C is the exposed facial nerve; D, mastoid process (sclerosed); E, carotid canal.

The roof of the middle ear—the tegmen tympani and tegmen antri—is often perforated by caries in cases of death from cerebral abscess (Fig. 203). The *outer wall of the attic*, especially at its lower edge, may be softened from caries in purulent affections of the attic.

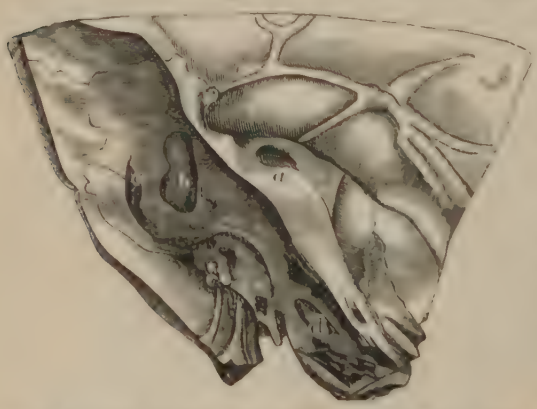

FIG. 203.—Left temporal bone, showing caries of roof and inner wall of mastoid cells, consequent upon suppurative disease of middle ear. *a*, carious opening in roof of tympanum; *b* and *c*, carious openings in inner wall of mastoid cells; *d*, internal auditory canal.

The ossicula are frequently affected with caries. The disease may be limited to a small carious spot in one of them, or the whole of the ossicula may be disarticulated and swept away. This may happen even as early as a few weeks after the beginning of the purulent process, especially when it originates in scarlet fever. It is not surprising that, when, as in purulent collections in the tympanum, the delicate small bones are constantly saturated with pus or loaded with granulation tissue, erosion or necrosis should take place, or that they should become

dislocated. Of the three ossicula, the stapes is least frequently lost; and its foot-piece generally remains, even after the head and crura are gone. The long process of the incus is particularly liable to destruction, owing to its length and slenderness. In disease of the attic the body of the incus is often affected with caries, along with the head of the malleus. The head of the malleus is more frequently destroyed than the handle; the latter, however, may be shortened by carious erosion of the lower end.

FIG. 204.—Inner half of section of temporal bone from a man who died of purulent meningitis consequent upon chronic suppuration of middle ear. *a*, Inner wall of enlarged antrum mastoideum; *b*, mastoid cells converted into ivory-looking bone; *c*, tympanic cavity; *d*, roof of antrum mastoideum; *e*, inner wall of osseous part of Eustachian tube.

Changes in the Antrum and Mastoid Cells. As the result of absorption by caries, or by the pressure of cholesteatomatous masses, or the removal of sequestra, great *enlargements* of the cavities of the ear may take place. The antrum mastoideum may be greatly widened, and the partition between it and the external canal destroyed or perforated. In such cases the enlarged cavity is usually occupied by cholesteatomatous masses, granulation tissue, and cario-necrotic debris. The accompanying woodcuts (Figs. 204 and 205) show examples of these effects. In the case from which these sections were taken there was also carious erosion of the inner or sigmoid wall of the antrum, and the sigmoid sinus was obliterated, leaving behind simply a fibrous cord. The mastoid cells proper were converted into dense ivory-looking bone. On the other hand, caries or necrosis may be asso-

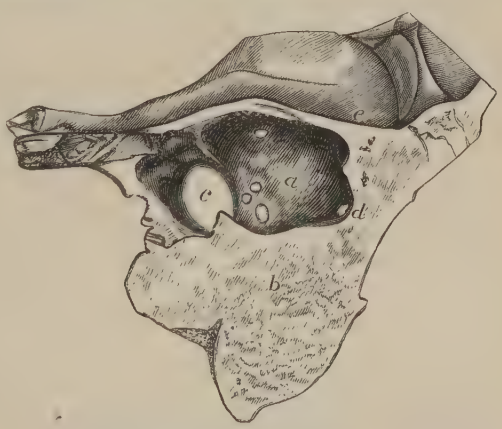

FIG. 205.—Outer half of the same bone. *a*, Outer wall of enlarged antrum, with carious perforations; *b*, mastoid cells converted into ivory-looking bone; *c*, lumen of external auditory canal; *d*, carious opening penetrating outer wall of antrum; *e*, dura mater.

ciated with new-formation of dense osseous tissue. The mastoid cells may then be converted into ivory-looking bone (see Fig. 205, *b*), and the antrum, tympanum, and even the external auditory canal may be much *diminished* in size or even *obliterated* by such hyperostotic growths resulting from caries or necrosis.

Caseous and Desquamative Collections. Another consequence of chronic purulent disease of the middle ear is the formation of masses, the products of changes in the purulent secretion which has lain there for a great length of time. These collections are found chiefly in the attic and antrum mastoideum: but they may exist throughout the whole middle ear. In many cases the purulent secretion simply dries, and, along with an abundance of epithelial cells desquamated from the mucous lining, becomes changed into caseous masses which have an offensive smell. This change may take place during the existence of the discharge from the ear, or the masses may gradually form out of the pus which has been retained in these parts of the middle ear after the discharge has ceased. Such caseous and desquamative debris is frequently found after death in persons who have suffered from chronic purulent disease of the middle ear.

Cholesteatomatous Masses. The purulent matter may undergo changes of a different character. Lying stagnant in these spaces for a long period of time it may undergo a fatty change with the formation of cholesterine, and, gradually inspissating, become converted into a substance like butter. Meanwhile, probably from the irritation caused by the pressure of the mass upon the walls of the middle ear, there is a rich proliferation and desquamation of epithelial cells, and, while the centre of the mass is formed of caseous-looking matter which is gradually drying, the outer or peripheral parts become changed into a firm mass composed of stratified layers of large flat cells, to which a glistening, mother-of-pearl appearance is imparted by the presence of crystals of cholesterine. These masses, from the firm consistence which they sometimes present, have been mistaken for real tumours, the *sebaceous* or *molluscous tumour* of Toynbee, and the *perltumour* of Virchow. But they are not true tumours—they are really altered pus, with exfoliated epithelial cells. We find in these cases broken down or laminated masses, inside the perforation, part of which may be removed with a small sharp spoon, or washed away with the syringe. The syringe may day after day for some time bring away such masses, often emitting an offensive odour.

These masses, enlarging peripherally, exert gradually increasing pressure on the walls of the middle ear, until the spaces of the middle ear, especially the antrum mastoideum, may become much distended from thinning and absorption of the walls. In time

they may extend beyond the confines of the middle ear into the external auditory canal on the one side; or by pressure upon the roof and inner wall of the middle ear the masses may force their way into the middle or posterior fossa of the skull, and bring about a fatal issue. Caries or necrosis is often associated with these masses, or may be the cause of their formation. A fatal issue may also result from the retention of pus, owing to such masses obstructing all means of outlet. They are found to swarm with streptococci and other micro-organisms.

Symptoms of Caries and Necrosis. The *subjective* signs of caries or necrosis are very much the same as those of purulent disease of the middle ear. In extensive necrosis or destruction of the ossicula, the deafness may be total, and if the osseous labyrinth be involved there is no perception by osseous conduction. Cases are recorded in which convulsions, presumably caused by the presence of necrosed bone, disappeared on its removal. While there may be complete absence of pain, there are, on the other hand, cases in which intense pain both in the ear and side of the head is complained of, not explained by such causes as acute inflammation or retained secretion.

The objective signs are more important than the subjective. In disease of the osseous walls or ossicula of the tympanum, when the affected parts are not exposed to view or accessible to touch, the objective appearances may be in no way different from those of chronic purulent inflammation of the middle ear, namely, the presence of secretion, partial destruction of the tympanic membrane, *presence of granulations*, etc.

In the external meatus there is often found a saccular or elongated bulging, which may be so large as to close the canal. This is caused by a collection of matter over the diseased bone under the periosteum. After this swelling bursts or is artificially opened, a permanent opening is left, over which granulation or polypoid tissue sprouts. With the probe introduced into the opening, we usually detect carious or necrosed bone or a sequestrum. Owing to a considerable amount of diffuse swelling of the cutaneous lining of the cartilaginous meatus there is sometimes great difficulty in reaching the deeper parts of the ear, especially in infants. On pressing a small speculum between the swollen walls of the canal we may only see red granulation tissue, which bleeds on touching with the probe, thus rendering the examination still more difficult. The probe reveals the existence of the bone mischief, either in the form of bare bone or a loose sequestrum.

In the mastoid process caries or necrosis more frequently manifests itself behind the auricle than in the external meatus, although it often exists in both parts at one time. It may begin on the surface

from an attack of periostitis, but more frequently it originates in the interior of the mastoid cells from inflammation leading to cario-necrotic destruction of part of the outer cortex. In either way a carious opening is the result, with or without the formation of a sequestrum.

An abscess generally forms over the diseased bone behind the auricle, from escape of the pus through the bone into the external soft parts, or from an infective periostitis. It is important to remember, however, that this is not always the case, for there may sometimes be no external change, and yet, on cutting down, extensive destruction of bone may be found on the outer mastoid cortex. When an abscess forms, the skin over the mastoid region, and sometimes extensively over the squamous and other parts in the neighbourhood, is more or less red, swollen, and hard at the early stage; or soft and fluctuating if the stage of purulent formation has been reached. The auricle usually projects outwards and forwards from the side of the head, being pushed out by the abscess and the swollen tissue immediately behind it. The osseous tissue in the neighbourhood, especially over the root of the zygoma, may be thickened, and carious centres may even be found there or at other parts more or less distant from the temporal bone. When an abscess forms, there will usually remain behind, after it has become evacuated, one or sometimes two or three sinuses through the soft parts, the openings of which are frequently concealed by granulation tissue and surrounded by more or less swelling. The openings into the sinuses may sometimes be covered with scales or crusts of dry secretion. A probe may require to be introduced to a considerable depth before it comes upon the diseased and perforated bone. The most common situation for the external opening of a sinus is the upper part of the mastoid process; but it may be at the lower part, or even below the auricle from the sinking of the abscess.

The glandular structures below and in front of the ear are often seen to be involved, especially in young children suffering from caries and necrosis of the mastoid. The glandular tissue may become much enlarged, and may be the seat of tubercular or of purulent formation.

In the same class of cases *facial paralysis* is common from involvement of the Fallopian canal.

Course and Consequences of Caries and Necrosis. The *Course* of the disease in the bone is sometimes very rapid. A large sequestrum may be formed in a few weeks from the beginning of the purulent disease, or, in as short a period of time, the whole of the ossicula may escape from the ear. The course is, however, most frequently slow, extending over a period of many months or years. The opening behind the ear sometimes appears closed for a time as if recovery had taken place; but soon the discharge again appears, the closure having

been due either to a scab or to a very thin bulging cicatrix. The exfoliation of a sequestrum is usually attended by distinct improvement in the purulent process. Severe inflammation, accompanied by intense pain, may attack the mastoid region during the course of the disease, from the pressure of cholesteatomatous masses, retention of secretion, irritating applications, or cold. When the disease over the mastoid process terminates in recovery, there is left a depressed firm cicatrix adhering to the bone. On examining this cicatrix with the finger, we usually find a distinct hollow in the bone.

The *Consequences* of the disease upon the cavities of the ear have been already spoken of. We shall further on have to describe more fully the possible danger to life, which may result from caries or necrosis. This danger is especially serious when the disease is situated in the osseous partitions which separate the dura mater and large vessels from the middle ear, at the roof and the inner wall of the tympanum. Facial paralysis, when due to purulent disease of the middle ear, is frequently brought about by caries or necrosis involving the osseous walls of the Fallopian canal. There has also to be mentioned the possibility of *lardaceous disease of the internal organs*, such as the liver or kidneys, being caused by long-continued caries of the walls of the middle ear.

Diagnosis of Caries and Necrosis. If the carious or necrosed part is within the field of vision, the practised eye may detect it.

The use of a probe, however, is often essential, and the sensation of roughness, and perhaps of mobility, may give positive evidence of the presence of necrosed bone or of a sequestrum, while the sensation conveyed by the touch of the probe on a gritty, soft, and depressed carious part, gives indication of the nature of the disease. In using the probe, where caries of the tympanic walls or ossicula is suspected, caution and gentleness should be exercised. We must on no account examine the tympanic structures with the probe without illuminating the interior of the ear, so that the eye may guide the hand. By the incautious use of the probe the tympanic membrane may be perforated, the ossicula dislocated, and the interior of the labyrinth, or even of the cranium, broken into. There is less danger in using the probe to the outer wall of the mastoid or the walls of the external auditory canal, except the upper wall, where, in consequence of the juxtaposition of the cranial cavity, only slight pressure should be exerted on any carious part.

The character of the discharge may sometimes yield information. It is often thin, brown, and *copious*, especially when a sequestrum exists. If it is frequently or persistently sanious, in the absence of granulations or polypi, there is ground for suspicion of diseased bone. An offensive odour from the discharge is not, as is believed by some, trustworthy

evidence of the existence of osseous disease. Fœtor of the discharge is, in most cases, merely an evidence of want of thorough cleansing, although, if the fœtor persist, in spite of repeated careful antiseptic cleansing, there is greater reason for suspecting caries or necrosis. Such fœtor may be also due to cholesteatomatous masses, which often at the same time occupy the attic and antrum.

The presence of *osseous particles* in the discharge shows the existence of caries or necrosis. These particles may be known to be present by a gritty feeling, when the pus is pressed between the fingers. Elastic fibres or osseous molecules may sometimes be recognized by the microscope.

Exuberant granulations, in some cases of the nature of polypi, are frequently found over the seat of caries or necrosis. So long as a carious disease exists, or a sequestrum remains, these growths, although removed, *quickly recur*. The cure of the caries, or the removal from the ear of the sequestrum, is, however, generally followed by spontaneous disappearance of the granulations or polypi. The ossicles may be embedded in granulation tissue, which often also occupies the antrum along with cario-necrotic debris and cholesteatomatous material.

The prognosis of caries and necrosis must be considered in view of all the possible consequences. While, in some of the situations mentioned, caries or necrosis is fraught with danger to life, experience has shown, on the other hand, that a carious disease may exist for many years, even from youth to old age, without any serious consequence, the patient dying from another disease altogether. In children there is a much greater likelihood of recovery both from caries and necrosis than in adults. The presence of a markedly scrofulous, tubercular, or syphilitic diathesis has, of course, a very unfavourable influence. In a very large number of cases of carious perforation of the cortex of the mastoid process behind the auricle, complete cure and cicatrization ultimately take place, either with or without operation.

TREATMENT OF CHRONIC PROCESSES IN THE MASTOID CELLS, ANTRUM, AND ATTIC.

This is, in many respects, the same as that of the secreting stage of purulent inflammation of the middle ear.

Cleansing and Antiseptic Remedies. The thorough cleansing away of accumulated or retained secretion, and the employment of antiseptic remedies, are of the first importance; and their prolonged use may act very beneficially on the osseous disease, and avert the need of operation when the disease is limited and superficial. In order to gain proper access to the interior of the ear through the external auditory canal, a slender india-rubber tube should be fixed to

the nozzle of the syringe, and introduced through the canal of the ear; or the small ball syringe (p. 68) may be employed, introduced well into the meatus. If the swelling of the walls of the canal is very great, efforts must be made to dilate the canal, either by introducing a series of cotton plugs, smeared with a suitable ointment (Formula 26), and gradually increasing in thickness, or, if necessary, by incising the most bulging portion of the swelling in the walls of the canal. It may be necessary to keep a proper drainage tube in the external auditory canal. Volkmann and Pritchard speak highly of the effects of instilling a weak solution of hydrochloric acid into the ear.

Operative treatment is, however, generally necessary, and the most frequent situation in which we have to operate is the *mastoid process.* If an abscess has formed either over the mastoid or squamo-mastoid area or in the posterior wall of the osseous portion of the external meatus, it should be freely incised, and an examination then made with the probe in order to ascertain the state of the bone. If we find, with or without abscess, a carious opening behind the ear, it should be operated upon as described at p. 97. If we have to deal with an acute condition, the thorough removal of cario-necrotic debris, pus, and granulation tissue, with subsequent dry dressing (see p. 95), will suffice. When based on a chronic condition, it may be necessary, after thorough operative treatment, including the removal of these inflammatory products as well as cholesteatomatous collections, to employ antiseptic or spirituous injections through the opening behind in such a way as to ensure thorough and complete cleansing and disinfection of the antrum, attic, and external auditory canal. The point of the syringe should be guarded with india-rubber tubing, and, if obstruction be found to exist, too much pressure must not be employed. Injection in the reverse direction may also be employed, that is, by fitting the nozzle of the syringe, guarded with india-rubber, into the external auditory canal, and forcing the fluid through the mastoid cells and out by the carious opening. The opening in the soft parts should be kept free from granulation tissue.

Sequestra should be removed. Care must be exercised in attempting to remove them from the external meatus. Repeated antiseptic syringing may suffice with small sequestra or exfoliated ossicula, and such syringing will often assist the separation of a sequestrum. If a long thin piece of necrosed bone lie across the canal, forcible pulling with forceps may thrust the points of the thin bone into the walls, injuring the skin of the canal, and possibly exciting severe inflammation. To avoid this, sequestra of such a shape and in such a position should first be crushed with strong forceps, after which removal becomes easy and safe. The remarks on the removal of foreign bodies (see p. 191) from the ear may here be referred to, and the

instruments there recommended are also useful in removing pieces of necrosed bone. If the sequestrum be in the interior of the mastoid process, with an opening in the cortex insufficient for its

Fig. 206.—Forceps for removing sequestra.

extraction, free access must be secured with the bur or gouge (see p. 94) in order to ensure its removal. In some cases of disease of the attic of the tympanum the ossicles, especially the malleus and incus, should be removed (see Excision of the Ossicles, p. 101).

Carious bone may be scraped from the posterior and inferior walls of the meatus, or from the edge of the Rivinian segment (the outer wall of the attic), with advantage and safety, but in the roof or inner tympanic wall this method of treatment should be done with special care. The sharp spoon of Wolf is the most suitable instrument. The galvanic cautery is sometimes employed to arrest a carious process of limited extent. After scraping or burning iodoform is a good dressing. When there is reason to suspect caries of the bony partitions separating the middle ear from the intra-cranial cavity—such as in the tegmen or at the sigmoid groove—it must be dealt with by thorough operative measures as described at p. 91.

Treatment of Desquamative and Cholesteatomatous Masses. If these masses are found, as they often are, filling the inner end of the canal of the ear, and adhering tenaciously to its walls, or to the interior of the perforation, long-continued ordinary syringing may be insufficient to dislodge them. The attic syringe (see p. 69) is here very useful. It may be introduced into the masses so as to inject fluid directly into them and assist in their separation and removal. A tampon soaked in glycerine and applied for twenty-four hours to the masses may facilitate their removal with the syringe, aided by forceps and a probe; frequent saturation for two days with a solution of bicarbonate of sodium, carbolic acid, and glycerine (Formula 89) is also a good way of preparing for their removal.

Treatment of Attic Disease. If these masses occupy the external attic or Prussak's space, it may be necessary to enlarge the space by scraping the softened edge of the *margo tympani* with a sharp spoon, which will also serve to remove any granulation tissue or cholesteatomata

contained in it. Politzer suggests the removal of the outer wall of the attic or of its lower edge by means of a special *forceps chisel* procured at Reiner's, Vienna. Schwartze removes the outer wall of the attic with a fine but strong chisel and hammer. In order to secure still better access to the attic and antrum, it may be necessary to extract the malleus and incus (see Extraction of the Malleus and Incus, p. 101), which in some cases are in a carious condition. When proper access is obtained, with or without extraction of the ossicles, the attic should be washed out by means of the attic syringe with a solution of carbolic acid, boracic acid, resorcin, corrosive sublimate, or peroxide of hydrogen (see p. 248), followed by the injection of a spirituous solution of either of the first three (Formulæ 77 and 81). Such injections may be repeated once daily for two or three weeks. The insufflation, through a fine tube introduced into the attic, of powdered boracic acid or of iodoform and boracic acid (1 in 4), has also been used by the author with advantage. He has likewise in some cases found it useful to stuff the attic with a fine strip of iodoform gauze or with pellets of medicated cotton. A thread is attached to the pellet to secure its removal, after twenty-four or even forty-eight hours, during which it may advantageously remain in the attic. If these methods of treatment do not put an end to the purulent process, the question of operating on the mastoid must be seriously considered (see Operations on the Mastoid, p. 91).

Constitutional treatment is frequently beneficial in these chronic processes in the mastoid. Any constitutional defect or cachexia must be treated by appropriate remedies. We shall usually find that such remedies as iron and cod-liver oil, with country air and nutritious food, are powerful aids to the local treatment. Iodide of potassium in quantities of from 8 to 15 grains daily is said by Politzer to be of great service in relieving pain.

PARALYSIS OF THE FACIAL NERVE.

We have included this among the consequences of purulent disease of the middle ear, because, when paralysis of this nerve is caused by an affection of the ear, that affection is most frequently purulent disease, especially when this is associated with caries or necrosis of the osseous walls of the Fallopian canal. It is met with less frequently in the acute stage of inflammation than in the chronic stages. Occasionally it is a consequence of non-purulent catarrh of the middle ear.

The intimate relation, both topographically and through the vascular supply, between the mucous membrane of the middle ear and the

nerve, as it lies in the Fallopian canal (see p. 209), explains how it may become involved in congestive or ulcerative diseases of the middle ear. When the paralysis is caused by a non-purulent disease, it is due either to hyperæmia of the sheath of the nerve, to the pressure of exudation, or to secondary contraction of the nerve: when caused by a purulent disease, it may be due to either of these, or to the pressure of necrosed bone, or to partial or complete ulcerative destruction of the nerve.

Signs of Facial Paralysis. The paralytic condition may come on suddenly, or there may be first twitchings in the affected muscles. The symptoms produced by pronounced paralysis are well known, and are chiefly due to the inaction of the facial muscles on the affected side. There is partial or complete inability to close the eyelids; drawing of the mouth to the normal side during facial movement; obliteration of the normal folds and furrows of the affected side of the face, especially the folds of the brow and the naso-labial furrow. These peculiarities are of course most marked during active facial movement (Fig. 207), as in laughing or crying, when the blank expression of the paralyzed side is very striking. Minor degrees of facial paralysis, such as a less distinct naso-labial furrow, associated with ear disease, are probably much more common than is usually supposed. Different fibres of the nerve, having different areas of distribution, may be unequally affected; thus the brow and the eyelids may be more markedly affected than the mouth or cheek, or *vice versa*. When the nerve-trunk is completely ulcerated, the paralysis is complete and permanent; on the other hand, if due to congestion or pressure, it may be partial and variable.

FIG. 207.—Left-sided facial paralysis, due to purulent middle-ear disease, with necrosis of the mastoid from which a sequestrum was removed.

The *uvula* is sometimes found to deviate to one side, while on the paralyzed side there may be defective movement of the velum palati during phonation. This is seen probably when the lesion of the nerve is situated above the *genu facialis*, from which

nerve twigs pass to the spheno-palatine ganglion, and thence to the uvula and soft palate. This symptom is, however, by no means constant. Besides, it may be found without facial paralysis, because impaired movement of the soft palate may be due to nasal and pharyngeal catarrh, and the uvula is frequently a little to one side even in health.

When the lesion of the nerve is situated above the origin of the twig for the stapedius muscle, there may be disturbance of the hearing and tinnitus aurium, caused by inaction of the stapedius muscle. The stapes is, in this case, found pressed inwards, owing to the tensor tympani being no longer antagonized by the stapedius. On the other hand, when the lesion is below the origin of the nerve to the stapedius, there may be abnormally acute hearing.

Fig. 208.—Bilateral facial paralysis (attempting to furrow the brow) in a man totally deaf from a central affection of the nerve.

Bilateral facial paralysis is occasionally met with in connection with ear disease. The cases seen by the author have been due to syphilis attended by very serious or total deafness, and in one instance ushered in by Ménière's symptoms (Fig. 208). The pathology of such cases is obscure.

The Course and Consequences of Facial Paralysis depend on the extent and character of the lesion. When due to congestive processes or to the pressure of exudation, it is likely to pass off in a few weeks. Even in these cases, however, it may remain either in a partial or complete degree permanent, owing to gradual thickening, contraction, or atrophy of the nerve or its neurilemma. If the paralysis prove permanent and complete, there may ensue in course of time atrophy of the facial muscles on the affected side, and even sometimes of the bones of the face.

Diagnosis and Prognosis. The *diagnosis* of unilateral facial paralysis is usually made at first sight. If facial movements are attempted, such as in laughing or whistling, even slight forms are readily distinguished.

If caries or necrosis exist, the *prognosis* is unfavourable, although

the paralysis is even then not necessarily incurable. Recovery sometimes takes place after the removal of a sequestrum from the ear. When connected with a non-purulent disease, the prospects are much more favourable—the paralysis usually coming on more gradually, being liable to fluctuations, and passing gradually away with the cure of the tympanic affection. If the lesion consist of actual destruction of the nerve trunk from ulceration, as in a purulent disease, the paralysis usually comes on suddenly, is very complete, and continues unimproved, even after the purulent disease of the ear has been cured.

The effect of the *electric current* upon the nerves and muscles of the paralyzed side of the face is important in prognosis. At first the irritability for both the galvanic and faradic current is diminished; after a week or two, however, the galvanic reaction is heightened, while the faradic continues diminished. As recovery takes place, the neuro-electric effect becomes less, while the myo-electric effect becomes greater. If there be no response to faradic stimulation, the paralysis may be looked upon as serious. It has to be mentioned that the appearance of facial paralysis in connection with ear disease is sometimes the precursor of fatal cerebral complication. In these cases it is usually intracranial in origin, partial in character, and *occurring on the opposite side from the ear disease.*

Treatment of Facial Paralysis. This must be directed chiefly to the removal of the ear disease, which is the cause of the paralysis. With this object in view, catarrhal or purulent disease or diseases of the bone must be properly treated. If recovery from the paralysis do not follow the cure of the ear disease, faradic electricity should be tried, as well as counter-irritation by means of repeated vesication by cantharides applied over the mastoid process, or of the liniment or ointment of iodine to the same region. Electricity is, in some cases, productive of benefit in these later stages of facial paralysis due to aural disease. The internal use of iodide of potassium (5 to 10 grain doses) is also said to have sometimes a beneficial effect, and should, in the more persistent forms, be tried.

CHAPTER XIII.

INTRA-CRANIAL AND VASCULAR INFECTIVE COMPLICATIONS OF PURULENT INFLAMMATION OF THE MIDDLE EAR.

When we study the anatomy of the middle ear (see p. 204), we can understand what a ready means for the extension of septic inflammatory disease is provided by the peculiar position and relations of the various parts of the interior of the ear, and how the structure of the temporal bone favours the accumulation and decomposition of purulent matter, the pathogenic micro-organisms in connection with which may invade the interior of the cranium or be absorbed into the general circulation.

It is important to remember that these infective processes generally originate in *chronic* purulent disease of the middle ear; *they rarely attend the acute stages* of the disease.

Mortality in Purulent Disease of the Ear. There is a general consensus of opinion that ear disease is the most frequent cause of cerebral abscess. In the synoptical record of seventy-six cases, given by Sir William Gull and Dr. Sutton, in their article on "Abscess of the Brain," published in 1872, in Reynolds's *System of Medicine*, twenty-seven cases, or rather more than one-third, were due to ear disease. In Lebert's article in Virchow's *Archiv* for 1856, Vol. x., based upon eighty cases of cerebral abscess, the proportion given as originating in ear disease is one in four. But in many of the cases not attributed to the ear, noted by these authors, the middle ear had not, it was evident, been examined, while in a considerable number the disease was said to have originated in a blow, which may be quite compatible with its real origin in ear disease. In the article in Reynolds's *System of Medicine* there are ten in which no cause is mentioned.

Statistical Authorities underrate Mortality. We know that up to the time at which these articles were prepared the ear was very little examined, either in the clinical wards or in the *post-mortem* room. We know also that purulent disease may exist in the middle ear without the knowledge of the friends of the patient, or even of the patient himself. Unless, therefore, the middle ear had been examined in every one of these cases, we are not in a position to say that these forty-seven cases in one hundred and fifty-six of cerebral abscess give a correct notion of the extent to which ear disease accounts for cerebral abscess. The

author is confident that persons die from abscess of the brain, originating in the ear, without the aural origin being known, because the friends of the patient may not be aware of the state of the ear, or may not deem the so-called "running ear" worthy of being mentioned to the medical attendant. Judging from the numerous cases scattered through medical literature and published within the past ten years, during which more close attention has been given to the ear in such cases, and also from the experience of our own hospitals, we are justified in attributing fully one-half of the cases of abscess in the brain to purulent disease of the ear. As time goes on, and as medical men come to use the ear speculum in every case presenting symptoms of cerebral disturbance, the frequency with which ear disease leads to a fatal issue will be found to be greater than has hitherto been suspected. In looking over the Registrar-General's annual reports, the author finds that the number of deaths in London attributed to otorrhœa, most of which would be due to intra-cranial infection, in one year was eighty-six; and in the eight principal towns of Scotland the number for one year was twenty-six. We are therefore entitled to conclude that these numbers, considerable as they are, do not express anything like the real number of victims to this disease who perish annually in London and the eight principal towns in Scotland.

The Pathways of Infection. There are two main directions by which extension takes place: first, by the *roof of the tympanum and*

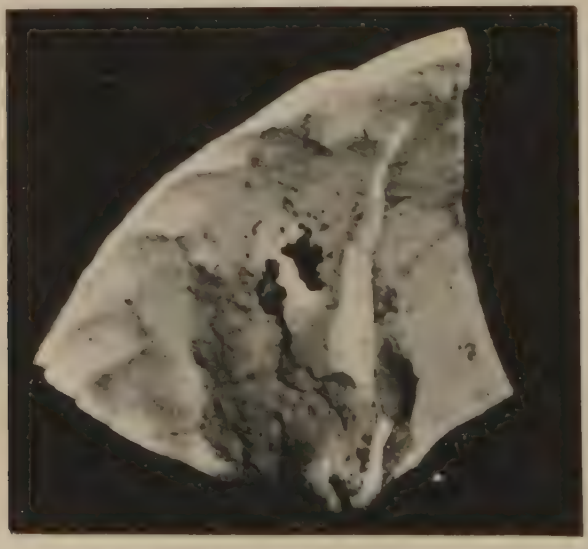

FIG. 209.—Carious apertures in roof of tympanum and antrum in a case of death from temporo-sphenoidal abscess.

antrum mastoideum (Fig. 209), to the middle fossa of the cranium, and the temporo-sphenoidal lobe of the cerebrum above; and, second, through the inner and posterior wall, *at the concavity for the groove of the sigmoid sinus* (Fig. 201), which separates the antrum and

adjoining mastoid cells from the sigmoid sinus and adjoining dura mater. As shown by the records of cases, these are the most frequent pathways by which the disease invades the interior of the cranium. In these situations the septic purulent focus is separated from the dura mater and sigmoid sinus by osseous partitions which are never thick, indeed frequently so thin as to be transparent, and which are always perforated with apertures for connective tissue, vessels, and nerves. Gaps are not unfrequently found, and at these the dura mater and the mucous membrane of the middle ear are in direct contact; while in childhood a very distinct fissure often exists at the tegmen tympani, the *petro-squamosal fissure*, through which a process of dura mater, with vessels and nerves, passes down and becomes continuous with the mucous membrane lining the tympanum. By simple continuity and contiguity, therefore, without a carious aperture, the pathogenic organisms may readily reach the dura mater and brain, giving rise to *extra-dural* or *subdural*, *cerebral* or *cerebellar abscess*; or to *septic thrombosis of the sigmoid sinus or other intra-cranial sinuses*.

Infection through the Labyrinth and Fallopian Canal. But, as has been already said, there is another pathway, by which the inflammatory or purulent process may pass to the intra-cranial cavity at the cerebellar fossa, namely, through the interior of the labyrinth (Fig. 202). The cochlea may be invaded through the fenestra rotunda, or through a carious aperture in the promontory. The vestibule may be broken into by ulcerative disease, extending through the structures closing the fenestra ovalis. Caries of the extreme upper and back part of the inner wall of the tympanum may convey disease to the interior of the horizontal semicircular canal. The disease, having reached the interior of the labyrinth, is separated from the dura mater at the *internal auditory canal* only by the perforated lamella of bone, through which pass the fibres of the auditory nerve. Instances are also recorded in which the disease passed from the tympanum to the internal auditory canal by the *Fallopian canal* and sheath of the facial nerve. By these routes the pathogenic organisms invade the cerebellar fossa and may give rise to *cerebellar* abscess.

Septic infection may also be conveyed to the *internal carotid artery*, contained in the carotid canal, which lies on the median side of the inner wall of the tympanum and osseous part of the Eustachian tube. Scarcely less important (as exposing the patient to the risk of septic infection) is the position of the *internal jugular vein* at its bulb exactly under the floor of the tympanic cavity; while of less, but yet of considerable, importance is the proximity of the *superior*

petrosal sinus, which is situated upon the upper edge of the petrous part of the temporal bone near to the roof of the middle ear.

Obstacles to Infection. Probably more frequent extension of infective middle ear disease to the dura mater and brain would take place, but for two causes: (1) The resistance offered to the microbic attacks by the strong fibrous tissue composing the dura mater; the power of resistance being often increased by a process of thickening of its tissue over the diseased ear, or by adhesion of the dura mater, pia mater, and brain at the carious perforation, or by the *formation of granulation tissue*. (2) The thickening of the lining membrane and osseous walls of the middle ear, by which the morbid process may, in the absence of caries, become circumscribed, and a barrier be provided against bacterial infection. Post-mortem examination has not unfrequently proved that caries and necrosis may exist immediately underneath the dura mater for a considerable time without producing more than a partial thickening of it.

Modes of Infection. In one or all of these directions there may be septic infection by *direct contact*, as in the case of a carious perforation, leading first to infective inflammation of the dura mater or walls of the sinuses, and then of the pia mater and brain. There is reason to believe that abscess in the cerebellum is usually the result of direct extension of the infective inflammation from the sigmoid sinus, in a state of purulent thrombosis, to the part of the cerebellum in contact with it. In many cases, however, no caries exists, and no visible track is seen between the septic focus in the ear and the infective lesion in the brain. The mode of infection may then be either through the foramina, fissures, or defects frequently found in the osseous partitions or *through the medium of the blood-vessels or lymphatics*.

Infection through the Blood-vessels plays a very important part.

As is well known, phlebitis and thrombosis are very apt to be set up in the vessels of a tissue which is the seat of septic purulent inflammation. The venous channels of the cranial bones and of the dura mater are especially liable to the formation of coagula in their interior. In consequence of this tendency, wounds of the scalp, followed by purulent inflammation, are regarded by surgeons as fraught with especial danger. Here, in the interior of the temporal bone, we have frequently the very conditions which are liable to give rise to changes within the blood-vessels, of which the formation of thrombi is the initial stage. These conditions are ulceration of the soft parts or of the bone, and the presence of decomposing pus with bacterial organisms in the immediate neighbourhood of great vascular trunks. The peculiarity of the circulation in the osseous partitions, between the dura mater and the mucous membrane of the middle ear, favours these changes. The blood supply to the bone is derived partly from the dura mater and partly from the mucous membrane, while the venous blood, including that from the *venæ diploicæ*, is discharged partly into

the veins of the dura mater and partly into those of the mucous membrane. In these ways free intercommunication takes place in the interior of the bony partitions between the vessels of the dura mater and those of the mucous membrane of the ear, so that morbid changes in the walls or contents of either set of vessels are pretty sure to be propagated to the other set. Hence, if phlebitis or thrombosis exist in the vessels of the diseased mucous membrane of the middle ear, it is very apt to be propagated by means of the vessels in the interior of the bone to the dura mater or its sinuses, especially to the sigmoid sinus. Indeed, probably some degree of phlebitis of that sinus is *a not unfrequent complication* of purulent disease of the middle ear. The mischief may, however, be limited to some thickening of the walls of the sinus, and to a consequent diminution of its lumen.

The Lymphatic Vessels may be the Medium of Absorption and Transmission, especially in tubercular disease of the middle ear or its bony walls. The blood-vessels of the brain are accompanied by these lymphatic vessels, or, as they are called, perivascular sheaths. Now, the internal auditory artery (the terminal branch of the basilar which ramifies in the pia mater close to the favourite seats of the tubercular deposits) inosculates freely with the stylo-mastoid artery, which furnishes the main arterial supply to the mucous membrane of the middle ear. In this way there is a ready lymphatic connection between the middle ear and the pia mater.

The great richness of the pia mater in lymphatic vessels must render it a particularly likely place for *tubercular deposition*. The infective agent, carried by the lymphatics from the ear, acts as a specific irritant upon the endothelium of the lymphatic vessels, and we have, as a result, infective inflammation, or, in the case of the tubercle bacillus, the formation of miliary tubercles. In the frequency of tubercle in the middle ears of children, intimately connected with and close to the base of the brain, may we not have an explanation of the otherwise mysterious preference of tubercle for the base of the brain?

There is a channel therefore, be it by blood-vessels or by lymph-vessels, through which infective matter absorbed in the ear may reach the brain, even when healthy tissue intervenes.

Under the designation **Intra-cranial and Vascular Complications of Purulent Inflammation of the Middle Ear** are included the following: (1) Abscess in the brain (cerebral and cerebellar); (2) septic lepto- and pachy-meningitis (including extra-dural and sub-dural abscesses); (3) septic thrombosis of the sigmoid sinus and other intra-cranial sinuses; (4) tubercular meningitis and general tuberculosis; (5) hæmorrhage from the internal carotid artery or sigmoid sinus.

ABSCESS IN THE BRAIN (CEREBRAL AND CEREBELLAR).

Abscess in the brain is most frequently met with in persons under thirty years of age, that is, when purulent disease of the ear mostly prevails.

The most frequent situation of the Abscess is a very important question. It is unfortunate that in many of the published records this information is not given with proper care and minuteness. The author has found, in the

published records of seventy-five cases of abscess in the brain due to ear disease, that the abscess was in the cerebrum, in the temporo-sphenoidal lobe just above the roof of the middle ear, in fifty-five cases, or about 73 per cent. of the whole: in the cerebellum, thirteen; in the cerebrum and cerebellum, four; in the pons Varolii, two; and in the crus cerebri, one case. In all, the abscess was on the same side as the ear disease. Rare cases have been recorded of the abscess being on the opposite side.

State of the Intervening Structures. The dura mater and brain substance intervening between the abscess and the source of the disease in the ear may be quite healthy; more frequently, however, the brain substance is dark, softened, or even necrosed, and the dura mater soft and pulpy. Over the roof of the middle ear the brain substance, dura mater, and bone may be firmly adherent to one another. The osseous partition between the middle ear and the dura mater is also usually dark in colour from the action, probably, of the bacillus pyocyaneus. If a carious opening exist, the dura mater over it may be simply soft, thick, and pulpy, or it may be perforated with small holes. Abscesses in the brain, where apparently healthy tissue intervenes between the abscess and the ear, probably owe their existence, as has been already explained, to the transference of bacteria from the ear by means of the blood and lymphatic vessels, or by septic embolism originating in a thrombus in the vessels of the ear.

In rare cases there has been found a fistulous communication between an abscess in the central part of the brain and a carious opening in the roof of the middle ear, when, by syringing the ear, liquid may be forced into the interior of the cranium. It was at one time believed that in such cases the abscess in the brain was the primary condition, and that, after making its way through the roof of the middle ear, it reached the external auditory canal, giving rise to the so-called "otorrhœa cerebralis." There is little doubt, however, that in all such cases the brain abscess was a secondary condition, resulting from purulent disease in the middle ear. The author examined the ear of a child, with copious purulent discharge from the ear, who presented symptoms of cerebral abscess, and found, each time after syringing and drying the ear, that pus oozed from the direction of the roof of the tympanum in such quantity as almost to immediately fill the canal of the ear. The skull was trephined and a tempero-sphenoidal abscess was found, but the child unfortunately died. It was then discovered that the pus cavity in the brain communicated, through an aperture in the roof of the middle ear, with the cavity of the tympanum.

The Contents and Walls of the Abscess. The contents are of the nature of dirty, greenish, decomposing pus, which usually emits a most offensive odour, probably due to the bacillus pyogenes fœtidus. In many cases there is a distinct limiting membrane, and the brain substance in the neighbourhood is often much softened, dark in colour, and necrosed. In the chronic *latent* forms there may be a *thick* pyogenic lining, encapsuling the abscess. Surrounding this, however, there is often encephalitis with softened, broken down, necrosed tissue due to the acute process which ultimately brought about the fatal result.

Exciting Causes of Abscess in the Brain. It has been noted that in addition to the predisposing cause—the purulent disease in the ear—there is also usually an exciting one which provokes the mischief in the brain. An injury such as a blow upon the head or ear, or an irritating influence acting upon the ear, is frequently found to

immediately precede the pain in the head and the vomiting which usher in the graver illness. In nine of the author's cases, one followed a box on the affected ear; one was due to a blow on the back of the head inflicted with the open hand; in another, the act of diving in the sea and the consequent rush of cold water into the affected ear, immediately preceded the head-symptoms; in two, the symptoms followed within two or three days of surgical manipulation in the ear, while, in the case of a boy, the exciting cause was probably connected with his fondness for "headers" in playing at football. In a certain proportion of such cases there may have been really a cerebral abscess in the latent form, existing perhaps for months or years, manifesting itself by no definite symptoms until the blow or irritation aroused a new and energetic process in the direction of increased formation of pus or of a fresh inflammation in the walls or in the vicinity of the abscess.

SYMPTOMS OF ABSCESS IN THE BRAIN.

In the Latent Form, in which the abscess may be encapsuled for months or even years, there may be, previous to the acute phenomena attending the later stage, few symptoms to indicate the presence of the abscess. In one of the author's cases the patient, a young man, was on holiday climbing the hills on the west coast of Scotland up to the onset of the acute symptoms, which ended fatally two weeks afterwards. From the character of the encapsuling membrane, Prof. Joseph Coats of Glasgow believed that the abscess had existed many months at least.

We find, on inspection of the ear, purulent secretion, usually fetid in character, in its interior, with more or less destruction of the tympanic membrane. We must not be satisfied with *inquiring* as to the existence of a discharge from the ear. Frequently the friends do not know that there is such a discharge, and even the patient may think that it has entirely ceased long ago, although the inspection of the ear yields ample evidence of the presence of purulent and decomposing secretion.

Pain in the Ear and Head. The first link in the chain of symptoms is usually that of a severe *pain in the ear*, continuing it may be for days, and shooting over the side of the head, merging into *pain in the head of a most severe character*. This is one of the most constant as well as distressing symptoms of abscess in the brain. The pain is often frontal, or it may be in the side of the head above the affected ear, when it may be increased by pressure or especially by percussion. In cerebellar abscess the pain has often its seat in the occiput or behind the mastoid region. While it is usually most intense and

continuous for the first few days or week, the pain rarely disappears entirely while consciousness lasts.

Vomiting is very rarely absent in the early stage, continuing for several days. It has the usual character of cerebral vomiting in that it is not specially associated with the taking of food. In cerebellar abscess the vomiting is particularly persistent and severe.

Shivering is usual, although this symptom is not as a rule so marked or prominent a feature as in infective thrombosis of the sigmoid sinus. It may only amount to a sensation of creeping cold in the back or to a slight and not long-continued shiver; if violent rigors take place, we should suspect the co-existence of thrombosis of the sinus.

Giddiness is often experienced; in cerebellar abscess it is generally a much more pronounced feature of the disease than in cerebral abscess.

The Digestive System is disturbed: the tongue is coated and the bowels are constipated. An offensive odour from the breath, which may be similar to the odour of the discharge from the ear, is frequently perceived.

Ocular Disturbance is rarely absent. Intolerance of light, with contracted pupils, characterizes the early stage; in the later phase of the disease, sluggishness and dilatation of the pupil on the side corresponding with the abscess, with inequality of the pupils, are often observed. *Optic neuritis* may or may not be present, but it is more likely to develop in the later stages. The *third nerve* on the same side is frequently involved in abscess of the temporo-sphenoidal lobe, leading to paralysis of the muscles supplied by it, resulting in dilated pupil, loss of accommodation, ptosis, and downward and outward deviation of the eyeball. The eyeballs are frequently observed to roll underneath the upper eyelid, and the eyelids are not quite closed.

Drowsiness. After a week or so the severity of the pain in the head usually diminishes and *the patient becomes drowsy*, although even then, when interrogated, he complains of pain in the head. The friends say that the patient is very drowsy, but that he apparently does not sleep. He can be easily roused, and answers questions intelligently and correctly, although his answers are *slow of coming* (slow cerebration) and *short*; he immediately falls again into a doze. Indeed, during the process of interrogation he tends to drowsily close his eyes.

The Temperature, at first somewhat elevated, becomes normal or even sub-normal in uncomplicated cases, until near death, when perhaps owing to the bursting of the abscess into the lateral ventricle, or, in the case of cerebellar abscess, into the fourth ventricle, or the

escape of its contents into the arachnoid cavity at the base of the skull, the temperature rises to a high degree.

The Pulse in typical cases tends to become *slow* after the first few days, this peculiarity becoming more remarkable as the abscess in the brain develops and increases, the beats being sometimes as slow as 40 or 50 in the minute. In the complications which usually attend the final stage, however, the pulse becomes very rapid and feeble.

The Respirations tend likewise to become abnormally slow, especially in cerebellar abscess, when, as death approaches, the respiration may entirely cease a considerable time before the heart-beat. Cheyne-Stokes' respiration is often observed.

General Convulsive Attacks are rare; but local stiffenings of certain muscles may be observed; and general tremors, more like severe shiverings, but probably convulsive in nature, are not unfrequent.

Coma. As the disease advances the drowsiness gradually deepens into *coma*. Sometimes there are intervals of consciousness followed by the comatose condition. Occasionally remarkable improvement appears to take place, rousing expectations of recovery. The author has seen a case in which the patient, after being comatose, recovered so far as to walk about for several days, lapsing again into drowsiness and unconsciousness, succeeded by death.

Paralytic Phenomena of a general character are unusual. There is sometimes pronounced hemiplegia affecting the opposite side of the body. This is, however, by no means common, although a degree of paresis of the arm and leg is probably more frequent than distinct hemiplegia. Paralysis of the ocular muscles has been already referred to in connection with paralysis of the third nerve. Unilateral paralysis of the face, partial or complete, is frequently seen at some stage of the disease. When due to implication of the Fallopian canal it is usually very marked, and is found on the side *corresponding* with the affected ear; if due to involvement of the cortex of the brain, the paralysis is on the *opposite* side, and is likely to be partial in character. The partially open eyelids of the one side, observed while the patient lies drowsy or comatose, may be the first indication of this paralysis. Paralysis of the sphincters generally precedes by a day or two the fatal termination.

Aphasia. In two of the author's cases *aphasia* was noticed. In one of them, which was examined *post mortem*, the convolution of Broca was not found involved directly in the abscess, but the pressure exercised on this lobe by the collection of matter in the immediate vicinity probably accounted for its function being disturbed.

Mode of Death. In uncomplicated cases *death* usually takes place by *coma*. In many cases, however, owing to the occurrence in the later stage of basal or general lepto-meningitis, due, it may be, to

the escape of pus into the arachnoid cavity, or to rapidly extending encephalitis, acute delirious excitement, extreme restlessness, elevated temperature, and other symptoms of meningeal inflammation may be the precursors of the fatal ending.

The Duration of cerebral abscess usually ranges from two to four weeks; but it also sometimes runs an irregular course for a longer period. As has been observed, it may exist in the latent form for a considerable period of time previous to the manifestation of the acute symptoms.

In Cerebellar Abscess there is often *retraction of the head*, while vertigo and vomiting, as has been already stated, may be more pronounced at the beginning of the disease. Yawning is a common symptom. There may be blindness with dilated pupils. Great prostration is also a notable feature of cerebellar abscess. Failure of the respiration, either from direct pressure of the abscess on the respiratory centre, or from sudden œdema of the parts in the vicinity of that vital centre, may be the proximate cause of death.

Emaciation. Great and rapidly progressing emaciation is a striking feature in persons suffering from abscess in the brain.

LEPTO- AND PACHY-MENINGITIS, INCLUDING SUB-DURAL AND EXTRA-DURAL ABSCESSES.

In Lepto-meningitis the inflammation affects chiefly the pia mater and arachnoid. It is frequently secondary to brain abscess or to sinus thrombosis. The inflammation may extend over the whole of the base of the brain and sometimes even over the convexity, lymph and pus occupying to a greater or less extent the meshes of the pia mater.

In Pachy-meningitis the inflammatory process is usually more localized in position, and it specially affects the dura mater, although the inflammation may ultimately involve the pia mater and brain, in which case it spreads inwards from the fine meshes of the inner layer of the dura mater. This extension would probably more frequently take place were it not that the frequent "soldering" of the dura mater to the arachnoid, pia mater, and brain presents a barrier to microbic extension.

Extra-dural Abscess. In external pachy-meningitis a collection of fetid pus often takes place between the dura mater and bone, either in the situation of the sigmoid groove, or over the roof of the middle ear on the floor of the middle fossa of the skull. In these situations purulent collections are termed *extra-dural abscesses*, which, when occurring in the situation of the sigmoid sinus, are usually associated with thrombosis of that sinus. The dura mater in these cases may be thickened and pulpy, or there may even be sieve-like perforations in it. Granulation tissue likewise may project from the outer surface of the dura mater, while the bone corresponding with the affected part is often darkened or eroded. The opening in the dura mater may communicate with an abscess in the arachnoid cavity or even in the brain. A cerebellar inflammation or abscess often extends directly from the sigmoid sinus, when it is in a state of septic thrombosis or when it is surrounded by a purulent collection.

Sub-dural Abscess. The purulent collection may form on the *inner aspect* of the dura mater, between it and the pia mater—this being termed *sub-dural* or *intra-dural abscess.* In these cases the brain substance corresponding with the abscess is usually softened, œdematous, and even superficially ulcerated, while the dura mater may soften after a time, leading perhaps to perforation and escape of the pus into the middle ear.

Pus in the Arachnoid Cavity. Pus may be found after death in the middle or cerebellar fossa of the skull in considerable quantity. This may have escaped from an abscess cavity in the interior of the brain through a perforation (Fig. 211). The pus in these cases may even find its way into the spinal canal as far as its lower end. When a cerebral or cerebellar abscess escapes in this manner into the arachnoid cavity violent lepto-meningitis follows, and many cases of brain abscess terminate fatally in this way.

SYMPTOMS OF LEPTO- AND PACHY-MENINGITIS.

In many respects the symptoms are those of abscess in the brain, and we shall refer to these symptoms in the same order as in describing abscess (see p. 293).

Pain in the Head is an early, severe, and persistent symptom, as in abscess. It is often in the forehead, but extends in many cases over the vault of the head; at other times the pain is more local, and it may be limited to the side corresponding with the ear affected.

Vomiting is rarely absent, continuing during the first three or four days; and, like the vomiting in abscess, it is not necessarily connected with the taking of food, the vomited matter usually consisting of mucus and bile.

Shivering or chilly creeping sensations are generally present; but there are no such intense and frequently repeated rigors as in infective thrombosis of the sinus.

Giddiness may be experienced in the early stages.

The Digestive System sympathizes, and there are generally great thirst and absence of appetite. The bowels are usually confined, and the *abdomen is frequently retracted.*

The Temperature is at first elevated, but its degree is variable; it is not so high as in septic thrombosis. There is often flushing of the face.

The Pulse is usually rapid, unless there is localized purulent formation, when a slow pulse, as in abscess, may prevail.

Tremors or Convulsions, with partial or complete unconsciousness and turning up of the eyeball, may take place at the early or later stages of the disease.

Local Rigidities and spasms, such as stiffness of the muscles of the neck and *retraction of the head,* are often observed. Complete hemiplegia is present in some cases.

Optic Neuritis is a common but by no means an invariable

phenomenon. The pupils may be sluggish, immovable, or unequal. Squint of an erratic character is often noticed.

Distinctive Symptoms. The mental functions in diffused lepto-meningitis become much involved. There are delirious excitement, extreme restlessness, perpetual movement in bed, and irritability. There may be drowsiness but no sound sleep. There are at the same time hyperæsthesia of the surface, intolerance of light, high temperature, quick pulse and breathing, terminating finally in coma and death. These symptoms contrast markedly with the deep drowsiness, the slow pulse, and the sub-normal temperature of abscess: there is, as in abscess, *great prostration.*

Modified Symptoms. Meningitis is frequently associated with abscess of the brain, or attended by pressure from extra-dural or sub-dural abscess. These symptoms may, on that account, be modified in particular cases; there may be thus the slow pulse of abscess with the elevated temperature of meningitis.

It is to be remembered that the whole of these symptoms are rarely present in any individual case; and, owing to complications, they may be very obscure. In extensive purulent lepto-meningitis the symptoms are extremely pronounced. In pachy-meningitis, on the other hand, since the disease is as a rule more localized, the symptoms are milder and fewer, while the course is slower than in lepto-meningitis. When the purulent collection is between the bone and the walls of the sinus, there is usually pain radiating from the sinus over the side of the head. Percussing the bone is generally painful, while pain on pressure depends on the thickness and density of the bone. Extra-dural or sub-dural abscess may be the precursor of lepto-meningitis, cerebral abscess, or septic sinus thrombosis. If the extra-dural abscess in pachy-meningitis be of some dimensions, the pressure exercised by it on the substance of the brain may lead to phenomena similar to those of an abscess in the interior of the brain.

The Duration of the disease is variable. Some cases terminate fatally in from three to four days, while others extend over as many months. Probably most cases run their course in from three to four weeks.

While the **Prognosis** is usually extremely unfavourable, experience shows that recovery may take place, even when, in the course of a purulent disease of the ear, such alarming symptoms as fever, headache, convulsions, and coma show themselves. Such cases, however, *are usually connected with acute*, not chronic, processes in the ear, and are probably of the nature of simple congestion of the meninges or brain, not attended by purulent formation.

Diagnosis. This disease cannot always be distinguished with certainty from abscess in the brain or infective sinus thrombosis.

Only in the typical uncomplicated cases can the distinction be made. Frequently, however, as has been already said, meningitis is complicated with one or both of the other intra-cranial conditions. It has been confounded at the earlier stages with typhoid or typhus fever ; but the progress of the disease and the history of the ear affection usually clear up any such diagnostic difficulty.

SEPTIC THROMBOSIS OF THE SIGMOID AND OTHER INTRA-CRANIAL SINUSES.

Circumstances favourable to Phlebitis and Thrombosis. When, as is frequently the case, the lining of the antrum and mastoid cells is chronically inflamed, softened, or eroded, and these spaces are occupied by decomposing purulent products swarming with septic organisms, it is not surprising that phlebitis and thrombosis with their effects should be set up in the sigmoid sinus, either by simple juxtaposition or through venous connections. Small thrombi, charged with infective organisms, may be carried inwards from the vessels of the mucous membrane of the ear or of the bones, until they project into the sinus, where fresh formations may take place, until it is filled by a large thrombus. This may extend from the sigmoid sinus down the internal jugular vein as far as the superior vena cava. But the coagulum may also extend upwards, either anteriorly through the superior petrosal sinus to the cavernous sinus, or posteriorly to the superior longitudinal sinus. The network of veins encircling the internal carotid artery in the carotid canal, and the superior petrosal sinus, which are in immediate relation with the mucous membrane of the tympanum, may also, in purulent diseases, be involved in phlebitis and thrombosis. From these veins the thrombi may pass to the cavernous sinus. It was suggested by Dr. Jas. A. Adams, of Glasgow, that thrombi with bacteria may be carried to the interior of the brain by the backward motion of the current of blood when the lateral sinus is obstructed or obliterated, giving rise to metastatic abscess. Lastly, from the floor of the tympanum the septic process may directly reach the bulb of the internal jugular vein.

Disintegration and Detachment of Thrombi. So long as the thrombus is firm and solid, obstructing the circulation, the danger of general blood infection may not be great ; but, when it becomes soft and disintegrated, general blood infection is imminent. The disintegrated and purulent thrombi detached by the current of blood, and laden with pathogenic organisms, are detained and become emboli in some near or remote part of the body, giving rise to a fresh purulent septic centre. In this way septic thrombi, swept on by the circulation, excite infarctions and metastatic abscesses, especially in the lungs. The kidneys, liver, spleen, joints, or subcutaneous connective tissue may, however, also be the seat of such infective abscess formations. Thus the general mass of the blood may be infected, giving rise to the phenomena of pyæmia or septicæmia. From the sinus on its median aspect purulent basic lepto-meningitis may arise, or cerebellar inflammation with abscess. External to the sinus a purulent collection may form, separating the sinus from the osseous partition forming its groove, and leading to erosion of the bone with the formation of granulation tissue.

Aseptic Thrombi. It is to be remembered, however, that thrombi, if aseptic, may be absorbed, leaving behind, it may be, thickening, contraction, or obliteration

of the sinus. In a case of temporo-sphenoidal abscess, observed by the author, there was complete occlusion of the sigmoid sinus, the walls of which were converted into a fibrous cord. There was also an extra-dural abscess at the sigmoid groove.

Infection through the Arterioles. It is also possible that septic inflammation, originating in the *arterioles* of the mucous membrane of the ear, may be propagated along the walls of the vessels as far as main arterial trunks, such as the internal carotid, the internal auditory, or the middle meningeal, giving rise to infected coagula, which may be swept along by the blood current till an embolic purulent centre is formed in the terminal twigs in the brain. In a case reported by Professor Gairdner and the author in the *Glasgow Medical Journal*, Vol. XXVIII., embolic lesions were found in the cerebrum connected with inflammation and thrombi in the internal carotid artery, traceable to purulent disease in the middle ear.

SYMPTOMS OF SEPTIC THROMBOSIS OF THE SIGMOID SINUS.

These are very much the symptoms which usually attend pyæmic poisoning, modified here by the situation of the source of the toxæmia.

Rigors. The most prominent and characteristic phenomena are frequently recurring and severe rigors followed by profuse perspiration. These rigors may occur every day or every two or three days, and each may continue as long as half an hour, during which the bed shakes and the teeth of the patient may be heard to chatter.

The Temperature is very high, but is subject to marked oscillations, being at one time, during the twenty-four hours, down perhaps to 101° and 102°, while at another it may reach as high as 105° and 106°.

The Pulse is also very rapid, and becomes small and weak as the general systemic infection increases.

Pulmonary Symptoms often develop in consequence of infarctions or abscess formations in the lungs, giving rise to hurried breathing and pain in the chest. Moist râles may be heard on auscultation. Expectoration, streaked with blood or having a "prune juice" character, giving forth in some cases a fetid or even gangrenous odour, is also a feature of this complication.

The Digestive System may in certain cases be seriously involved. There is generally vomiting in the early stages. Not only is the tongue dry and coated, but there may be severe *diarrhœa* with abdominal pain. On account of the diarrhœa, as well as the marked typhoid phenomena which often attend such cases, the disease may simulate enteric fever. The headache, however, is generally of a more intense and prolonged character than in enteric fever.

Headache is in most cases a prominent symptom, although it is neither so severe nor so continuous as in cerebral abscess or meningitis. When, however, the disease is complicated with meningitis,

which it not unfrequently is, there may be most violent pain in the head, but the rigors in these cases may not be so marked.

Pain is often produced by *percussion* or *pressure* over the posterior part of the mastoid, in the region of the sigmoid sinus and the mastoid foramen. There may also be pain on pressure over the upper part of the posterior cervical triangle.

Œdematous Swelling is sometimes seen on the side of the head, in the temporal region, or extending from the mastoid process to the back of the head. This œdema is caused by obstruction to the flow of blood through the emissary veins of the skull.

Pain and Swelling over the Internal Jugular Vein. Over the upper part of the jugular vein tenderness is often elicited by pressure, and a hard *cord-like swelling* may be felt at the inner edge of the sterno-mastoid muscle, although secondary foci may form in other parts of the body without *apparent* involvement of the jugular. Indeed, the more marked the thrombus, the less the intensity of the infection. In certain cases there is found in this region matting together of the tissues with a brawny swelling, leading sometimes to abscess. This should be distinguished from the abscess which may form under the deep cervical fascia in connection with perforation of the inner wall of the lower part of the mastoid (Bezold's perforation).

Giddiness is also in this disease not unfrequently experienced.

The Skin is usually dry and somewhat yellowish. After the rigors, however, it becomes bathed in perspiration.

The Intellect may remain quite clear to the end, if the disease be uncomplicated with abscess in the brain or meningitis.

Special Symptoms from Secondary Foci. From *secondary foci* in the brain, lungs, and other organs, special symptoms may develop. In the advanced stage one or more abscesses may occur in the cerebrum or cerebellum, or lepto-meningitis may be set up. In all such mixed cases it is to be noted that the symptoms of the thrombosis generally predominate and mask the symptoms of the other conditions. The meningeal symptoms may, however, predominate in some cases. There are cases of a comparatively mild character, where there is intermittent and not great elevation of temperature—cases in which the thrombus or coagulum entirely plugs the sinus and stops the circulation within it. When, however, the blood-clot disintegrates and softens, the infective material is loosened and carried down to the lungs or other distant organs, giving rise to such grave symptoms as violent rigors, great elevation of temperature, rapid and weak pulse, and pulmonary symptoms if the lungs be involved. It is to be remembered that, as all these conditions may co-exist, namely, infective sinus thrombosis, meningitis, and

brain abscess, the symptoms may not present the typical character of one or other of these conditions. The thrombosis, if present, generally gives the character to the disease; if absent, and the other two are present, the meningeal phenomena will probably mask the symptoms of the other.

Symptoms peculiar to Thrombosis of the other Venous Sinuses. When the *internal jugular vein* is obstructed by a thrombus, the external jugular and the veins of the neck and cheek may be at first dilated, with, in some cases, swelling of the cheek and eyelids, owing to the over-distension. After a time this dilatation disappears, from the establishment of a collateral circulation, diverting the blood to the opposite internal jugular. This venous stasis may also produce a colourless swelling, very tender to pressure, on the side of the neck along the inner edge of the sterno-mastoid muscle. In some cases a hard cord is felt by the finger in the course of the internal jugular vein. The pressure of the thrombus upon the nerve trunks passing through the jugular foramen, in company with the internal jugular vein, sometimes produces characteristic symptoms. Various observers have thus reported the existence of phenomena due to irritation or paralysis in the regions supplied by the vagus, glosso-pharyngeal, spinal accessory, or hypoglossal nerves.

The symptoms of thrombus in the *cavernous sinus* may be very numerous and varied, being produced either by stasis of its venous blood or by pressure upon the nerves lying close to the sinus. Stasis of the blood explains the occasional existence, in connection with this form of thrombosis, of exophthalmos, temporary blindness from œdema of the retina, and swelling of the forehead, eyelids, and nose; while pressure of the thrombus upon the abducens nerve or on the oculo-motor may cause, in the former case, turning in of the eye-ball from paralysis of the external rectus muscle, and, in the latter, the symptoms of internal and external ophthalmoplegia, namely, paralysis of accommodation, dilatation of the pupil, ptosis, and downward and outward squint.

When the thrombosis extends to the *superior longitudinal sinus*, serious symptoms may arise, such as epileptiform or apoplectic phenomena, probably due to effusion into the cortex of the convexity of the brain from obstruction to the flow of blood through the sinus. In children there may be bleeding from the nose, owing to the fact that in childhood part of the venous blood from the nasal passages is discharged into the superior longitudinal sinus, and the stasis of the venous circulation in the nose caused by obstruction of this sinus leads to hæmorrhage. From the same cause the veins passing in childhood from the anterior fontanelle to the temples and auricle may be dilated and prominent.

Course. Septic thrombosis may have a rapid course, terminating fatally in a few days by the paralyzing influence of blood poison. The course of the disease, however, more frequently extends to two or three weeks, death usually taking place by pyæmia, metastatic abscesses in the lungs, liver, kidneys, or *the brain itself.*

Diagnosis and Prognosis. When no objective symptoms of thrombosis of the venous sinuses of the head are present, the diagnosis is somewhat difficult. For a time it may be confounded with typhus or typhoid fever. From meningitis or cerebral abscess it may be distinguished by the more pronounced rigors in phlebitis, as well as by less disturbance of consciousness and motor power.

There is no doubt that a certain degree of phlebitis, in connection with purulent ear disease, leading to thickening of the coats of the vessels and to thrombi, especially in the sigmoid sinus, sometimes exists without a fatal issue. This may be owing to the plug in the vessel obstructing the circulation, and so preventing systemic infection. Indeed, this is probably a much more frequent complication of ear disease than is usually supposed. Wreden, as the result of his observations, puts the numbers as high as 14 per cent. of chronic purulent disease of the ear. Dusch found that, out of thirty-two cases of thrombosis, twenty originated in purulent disease of the ear. If metastatic abscesses have formed in the brain, lungs, or liver, the issue of the case will be almost certainly fatal.

TREATMENT OF INTRA-CRANIAL AND VASCULAR COMPLICATIONS OF PURULENT DISEASE OF THE MIDDLE EAR.

Till eight years ago the treatment of these conditions was almost limited to the relief of symptoms, but it was rarely successful in saving the patient's life. No doubt cases of meningitis due to *acute* purulent conditions in the middle ear may be beneficially and perhaps successfully treated by cold applications to the head, local abstraction of blood, purgatives, sedatives, and counter-irritation. The prospects of patients suffering from these complications have much improved, however, since 1887, when operative treatment was inaugurated in Great Britain by Prof. Macewen of Glasgow; by Mr. Barker and Mr. Victor Horsley of London; and by Mr. Caird of Edinburgh. The inauguration of these operative measures proved a brilliant epoch in the history of surgery, and during the past seven or eight years very many lives have been saved in all parts of the world by the adoption of the operative methods of dealing with these complications.

History of the Operative Treatment. Probably the first two recorded cases of operations for the removal of a collection of pus from the intra-cranial cavity originating in purulent disease of the ear, was that by Schondorff in the

Monatsschrift für Ohrenheilkunde, 1885, No. 2, and that by Truckenbrod in the *Archives of Otology*, 1886. In both of these, however, there were *external indications* of the seat of the abscess, in the form of fistulous openings with œdema on the surface of the head. To Arthur E. J. Barker of London, however, belongs the credit of first successfully, and with the effect of saving the patient's life, removing a collection of pus from the inside of the skull, connected with purulent disease of the middle ear, *when no carious aperture or superficial swelling on the surface of the head* guided him as to the seat of the abscess in the brain. This case was reported in the *British Medical Journal*, 11th December, 1886. The abscess was in the right temporo-sphenoidal lobe. Healthy brain tissue was penetrated to the depth of half an inch when fetid gas and pus were evacuated. The trephine opening was made an inch and a quarter above and behind the external orifice of the ear.

Since this important success, which may be termed an epoch-making case, a series of successful cases have been put on record mainly in Great Britain. These appeared much in the following order. Caird of Edinburgh, reported by Greenfield in the *British Medical Journal*, 12th February, 1887, operated for abscess of the left temporo-sphenoidal lobe in a man twenty-six years of age. Wm. Macewen of Glasgow followed shortly afterwards in the *Lancet*, of 26th March, 1887, with a case of the author's. It was that of a boy ten and a half years of age, in whom there was an abscess in the right temporo-sphenoidal lobe. On 10th March, 1888, David Ferrier of London published another case in the *British Medical Journal*, in which Victor Horsley operated on abscess in the left temporo-sphenoidal lobe, in a man aged forty-seven. Barker next reported a case in the *British Medical Journal*, of 14th April, 1888. This was one of meningeal effusion, in which he evacuated inflammatory fluid from the deeper part of the island of Reil, on the right side, in a man thirty-three years of age. The next case fell to the lot of Macewen, on 15th of May, 1888, and was shortly described by the author at the Otological Congress in Brussels, in 1888 (see *Quatrième Congrès International d'otologie*, p. 171). It was that of a man, aged twenty-one, from whose right temporo-sphenoidal lobe, Macewen removed three ounces of fetid pus. Another case followed in the *British Medical Journal*, 20th April, 1889, operated upon at Liverpool by Jordan Lloyd, in which four ounces of bad smelling pus were removed from the left temporo-sphenoidal lobe. Another remarkable case of Macewen's was reported by the author in the *Archives of Otology*, No. 3, 1889. This was unique in respect that it was the first case in which a *cerebellar* abscess due to ear disease was successfully operated upon. It occurred in a young man, seventeen years of age. Four ounces of pus were liberated from the left lobe of the cerebellum. E. von Bergmann, Berlin, reported in the *Deutsche Medicinische Wochenschrift*, 1888, No. 50, an otitic brain abscess successfully operated upon. Other two successes were recorded by Urban Pritchard in the *Archives of Otology*, No. 2, 1890. The first was that of a young man, aged twenty three, in whom four trephine openings were made on the left side by Mr. William Rose, and a cerebral abscess drained. The second occurred in a young man, aged twenty-six, from whose left temporo-sphenoidal lobe Mr. Cheyne removed about half an ounce of fetid pus, followed by recovery. Since that, there has been a brilliant record of life-saving work in this department. In the various medical journals, the author has found *records of* 158 *cases* in which operations followed by complete recovery have been performed for the relief of the intra-cranial complications of purulent ear disease. We are justified in

believing that, in addition, there have been many unrecorded cases; some such cases are known to the author.

The Scope of Operative Treatment. At the present stage in the history of the operative treatment of intra-cranial lesions due to ear disease, it may be said that we are able to reach and deal successfully with the following conditions: (1) Abscess in the cerebrum, especially in the temporo-sphenoidal lobe; (2) abscess in the cerebellum; (3) purulent formations at the base of the skull, either (*a*) between the bone and the dura mater (the so-called extra-dural abscess), or (*b*) between the dura mater and the surface of the brain (the sub-dural abscess); (4) infective thrombosis of the sigmoid sinus, even when secondary foci may exist elsewhere.

Preliminary Opening of the Middle Ear. In some of these conditions we are able to reach the abscess most conveniently from the cavities of the middle ear; in others we can deal with it more satisfactorily through a trephine opening in the lateral wall of the skull above or behind the middle ear.

In *all* of these conditions it is essential, as a preliminary operation, to explore the cavities of the middle ear by removing the outer wall of the antrum. With the cavities of the middle ear thus opened we ought to scrutinize with good light and a reflecting mirror the bony partition which separates the tympanum and antrum at their roof from the dura mater, as well as (and this is perhaps more important still) the bony partition at the sigmoid groove. The existence of a carious aperture, of an exposed dura mater or sigmoid sinus, or of granulation tissue sprouting from these, will regulate the further procedure. The partitions of the roof and sigmoid groove, separating the middle ear from the temporo-sphenoidal lobe above and the sigmoid sinus behind, are the two great pathways by which the infective matter effects its fatal entrance to the interior of the cranium. Fortunately they are both readily accessible from the middle ear spaces; and, by the preliminary and essential operation of opening these spaces, we are able to remove the pus, cholesteatomatous matter, granulation tissue, carionecrotic debris, and the pathogenic organisms from the antrum and attic.

Modes of Operating—the Rotating Bur. In the presence of symptoms pointing to abscess, meningitis, or septic thrombosis, we must, from the middle ear spaces, boldly and without hesitation, open the vulnerable bony partitions and follow up the path of invasion. This is done with great safety and efficiency by means of the rotating bur propelled by a dental engine, supplemented by the use of a good sharp gouge, as described at page 94. By simple and judicious extension of the operation for exposing the cavities of the middle ear, we can, in many cases of intra-cranial complication from purulent ear

disease, reach the seat of mischief and deal satisfactorily and safely with it, and in all cases such exposure of the middle ear (antrum and attic) with opening of the cranial septa should take place before proceeding to the use of the trephine.

Extra-Dural Abscess. Having broken down the cranial partitions we find, in a certain proportion of cases, pus between the dura mater and bone, extra-dural abscess, in one or other of the vulnerable situations. Above the tegmen antri or tegmen tympani pus is often found extra-dural, the removal of which, without going deeper, brings about the disappearance of grave symptoms. Such extra-dural formations may be the precursors of temporo-sphenoidal abscess, just as similar formations at the sigmoid groove often lead to septic thrombosis of the lateral sinus, general septicæmia, or cerebellar abscess. Operations for the removal of extra-dural abscess have been singularly successful, and during seven years thirty-nine cases have been reported of extra-dural abscess either at the tegmen or at the sigmoid groove operated upon and followed by recovery.

Operating upon Intra-Dural Abscess. Further exploration, by opening the dura mater at the tegmen of the middle ear or behind the sinus, will depend upon the symptoms, as well as the conditions, found present. In the presence of symptoms of lepto-meningitis such extension of the operation may reveal purulent formations between the dura mater and brain, in one or other of these localities, the removal of which may save the patient. No doubt the purulent exudation in such cases is generally too diffused to be susceptible of thorough removal, and these are certainly the least hopeful of all intra-cranial complications of ear disease, yet the experience of Professor Macewen and others has shown that localized purulent collections in lepto-meningitis may be removed, with the result of saving the patient's life. If granulation tissue be seen protruding from the exposed dura mater, careful inspection should be made, when a sinus may be found leading into the arachnoid cavity. The discovery of such a sinus would call for the free opening of the dura, and in the event of purulent formation, with, perhaps, ulceration or erosion of the surface of the brain, being found, thorough cleansing and antiseptic treatment of the interior would give the patient a chance, as shown by the fact that sixteen cases of successful operation are recorded for the relief of purulent collections due to lepto-meningitis.

Septic Thrombosis of the Sigmoid Sinus. It may be said that extra-dural abscess in the situation of the sigmoid groove is generally associated with septic thrombosis in the sigmoid sinus, hence in all such cases the sinus should be carefully examined. If found to be occupied, as it generally is, by a thrombus, and if symptoms exist pointing to disintegration of the clot and general septic infection, the

blood current, if still flowing through the sinus, should be stopped, in order to prevent further systemic infection. This is achieved either by ligature of the jugular vein in the neck, as first proposed by Victor Horsley; or, as advocated by Macewen, slitting up the freely exposed sinus, removing the septic thrombus, stuffing with iodoform gauze, and by pressure bringing the outer wall of the sinus into contact with the inner, thus obliterating the venous tube. If there is reason to believe that the sinus is quite occluded, and the circulation entirely checked, the simple application of antiseptics and pressure may suffice. In the hands of Victor Horsley, Arbuthnot Lane, Ballance, and others, the operation of ligaturing the jugular vein, laying open the sinus, and clearing out the clot, has proved very satisfactory, saving the patient in some cases even when secondary foci had been formed. There are now thirty-six recorded cases of successful operation where septic thrombosis and general infection existed.

Cerebral or Cerebellar Abscess. In the presence of symptoms pointing to abscess in the temporo-sphenoidal lobe or in the cerebellum (and the diagnosis of an uncomplicated abscess in the temporo-sphenoidal lobe may now almost be said to belong to the region of certainty), no time should be lost before we open the abscess cavity by means of a cannula and trochar or hollow needle, remove its contents, and, as far as possible, cleanse and disinfect the interior. In dealing efficiently with such abscesses in the temporo-sphenoidal lobe, or in the cerebellum, a trephine opening is required in the lateral part of the skull above the ear, or, in the case of the cerebellum, behind the sigmoid sinus. In temporo-sphenoidal abscess it is usual to remove with a trephine a half-inch disc of bone, at a point one and a half inches above and half an inch behind the centre of the external auditory canal. The dura mater is opened and a trochar thrust downwards and inwards in the direction of the middle of the upper surface of the petrous bone. Another opening is sometimes made lower down through the roof of the antrum. Macewen puts great stress on thoroughly washing out the abscess cavity with a solution (1 to 40) of carbolic acid, the liquid escaping through a second cannula introduced lower down (von Bergmann is opposed to syringing), until the escaping fluid is quite *free from the odour of decomposition.* Frequently shreds of sloughed brain tissue have to be removed with forceps. Two decalcified chicken-bone drainage tubes are inserted and stitched to the external soft parts so that the outer ends are flush with the skin. A powder composed of iodoform and boracic acid is freely sprinkled over the wound, and a wood wool pad is applied. After this operation Macewen prefers to have as few dressings as possible, and in some of his successful cases he has not removed the dressings for two or

three weeks, when the wound was found to be healed. Re-implantation of fragments of bone, as first employed by Macewen, may be tried in the opening from which the disc was removed. The encapsuled abscesses are of course the most favourable for operation. Barker says that an inch above and behind the meatus would include the greater part of most cerebral abscesses, and from within this area they would be reached by trephine and trochar. Barker has treated this subject fully and ably in his *Intra-cranial Inflammations starting in the Temporal Bone*, London, 1890. In his recent work, *Pyogenic Infective Diseases of the Brain and Spinal Cord*, 1893, to which the reader is referred for further information, Professor Macewen says, "In uncomplicated abscess of the brain operated on at a fairly early period recovery ought to be the rule."

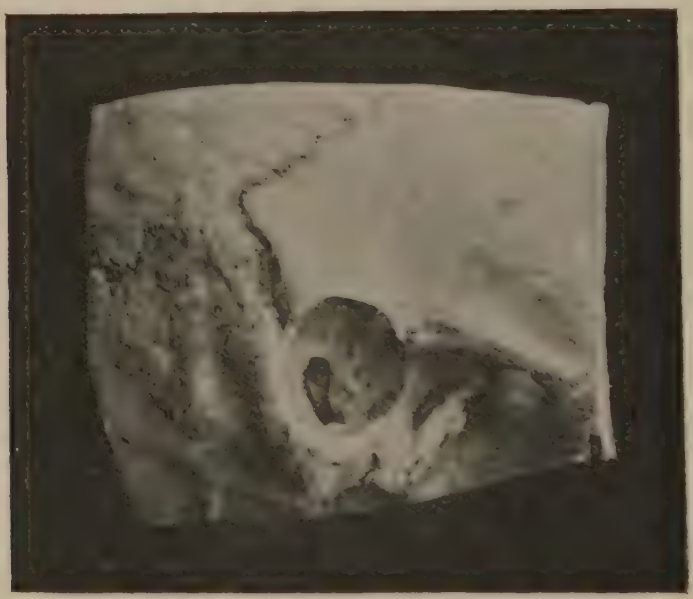

FIG. 210. Temporal bone, showing large opening made with bur and denta engine, leading into antrum and attic, with two branch openings; the one behind exposed the sigmoid sinus, and the other, further in, exposed the dura mater over the roof of the antrum. Patient died from cerebral abscess and purulent meningitis.

Treatment of Mixed Intra-Cranial Conditions. It is to be remembered, however, that many cases are of a mixed character. We often have abscess formation in the brain, along with lepto- or pachymeningitis, or with septic thrombosis of the lateral sinus, or the whole of these conditions may exist at the one time in the same patient. If lepto-meningitis exist along with abscess in the brain tissue, the symptoms of the latter are masked by those of the former, and we are apt to conclude that we have to deal with a

pure meningitis, and decide against operation. The experience of the author, however, would incline him to the view that, although the symptoms may be those of lepto-meningitis, our duty is to expose the middle and posterior fossæ of the skull, and search for pus.

The author had a case, a woman, twenty-eight years of age, who had suffered from a purulent disease of the right middle ear from early childhood. She was seized with symptoms of intra-cranial mischief. There were vomiting, intense pain all over the head, rigors on three occasions, persistently elevated temperature, quick pulse, delirium with unceasing movement, and entire absence of sleep. In fourteen days from the apparent commencement of the intra-cranial mischief these symptoms terminated in death. Immediately after seeing her for the first time, the author opened the cavities of the middle ear with the bur, and removed fetid purulent matter and inflammatory debris. He exposed the dura mater at the roof of the antrum and also the wall of the sigmoid sinus—these openings are seen in Fig. 210. There was no thrombosis of the sinus, and no pus between the dura mater and bone in either situation. As the symptoms did not seem to point to abscess in the brain, but rather to meningitis, he proceeded no further. On examining the interior of the skull after death, while extensive lepto-meningitis on both sides, with lymph and purulent deposit, was found, there was likewise an abscess in the temporo-sphenoidal lobe, the pus from which had partially made its way through two perforations in the base of the lobe into the middle and posterior fossæ, and also into the spinal canal (Fig. 211). From the thickness of the pyogenic membrane lining the abscess, there was reason to believe that the abscess had existed for a considerable time before the onset of the symptoms of intra-cranial mischief, and the lepto-meningitis was evidently set up by the escape of the pus into the sub-dural space. While the trephining of the skull would not have saved this patient at the time she came under observation, it would perhaps, from the surgical point of view, have been more satisfactory had the collection of pus been exposed and drained as far as possible. It is even conceivable that, at a very early stage of the symptoms, the meningitis might have been checked and the patient's life saved by the thorough removal and drainage of the contents of the abscess and the antiseptic treatment of the affected parts.

FIG. 211.—Base of brain from patient whose temporal bone is depicted in Fig. 210. Two perforations are seen in base of right temporo-sphenoidal lobe, through which pus escaped on to the base of the skull from an abscess in the interior of the lobe, which is also seen to be larger and broader than on the other side. A purulent deposit is also depicted on the cerebellar surface, due to the lepto-meningitis.

The Present Trend of surgical opinion is that we shall rarely go wrong if, in the presence of grave intra-cranial symptoms evidently connected with a chronic septic process in the middle ear, we explore the various pathways by which the disease invades the interior of the skull. If no extra-dural collection be found, or, when found, if its removal be not followed by marked improvement, we should open the dura mater and examine the sub-dural space; even then, if the results be negative, we need not hesitate to explore the temporo-sphenoidal lobe or cerebellum or both.

The Record of Work during the past seven years in the operations for cerebral and cerebellar abscess has been remarkable. At least fifty-nine cases of cerebral and seven cases of cerebellar abscess have been thus successfully treated. Many of these were associated with septic thrombosis of the sigmoid sinus, some with meningitis.

Tuberculosis. We have already referred to the probability of the tubercle bacillus in the middle ear or temporal bone being conveyed by the lymphatics to the pia mater and producing tubercular meningitis. It is possible that even general tuberculosis may have its infective source in the middle ear.

The late von Tröltsch, of Würzburg, related in Virchow's *Archiv*, so far back as 1859, three cases of acute miliary tuberculosis occurring in persons who suffered from chronic purulent disease of the middle ear. At that time he suggested, before he was aware of the existence of the tubercle bacillus, that some cases of tubercular disease might be due to the absorption of inflammatory products formed in the ear. He asked the question, "Whether many cases of suddenly-beginning and rapidly-developing tuberculosis might not generally be due to an infection of the blood from a purulent collection at some part of the body?" It was also remarked by him that, in tracing the history of patients who have had otorrhœa, he observed that many of them died young. In such he found that tubercular meningitis, or tuberculosis of the lungs or of the bowels, was generally the cause of death.

No doubt there have been many cases observed, in which tubercular meningitis or acute miliary tubercle occurred in persons, who were suffering from, or had been suffering from, purulent disease of the middle ear. In all such cases, however, it may be fairly urged that the existence of the disease in the ear is a mere coincidence, having no etiological relation to the tubercular disease. Or it may be reasonably maintained that the disease in the ear is a manifestation of the same constitutional tendency which produced the tubercular disease that, in fact, instead of being the cause of the tubercular disease, the ear disease is the result of the tubercular tendency in the system.

Nevertheless, the presence or absence of caseous or tubercular collections in the middle ear should be made a point for investigation in the case of persons who have died from tuberculosis, and especially from tubercular meningitis.

Hæmorrhage from the Ear. Thirteen cases of fatal bleeding from the ear in connection with chronic purulent disease have been recorded (Hessler). These were all associated with carious disease, either of the osseous partition separating the mucous membrane of the middle ear from the internal carotid artery, or of that separating it from the sigmoid sinus. The carotid artery is the most frequent source of hæmorrhage, and the perforating ulcer in its walls is generally at the

angle formed by the perpendicular and the horizontal parts in the carotid canal. Ulceration of the sigmoid sinus or jugular bulb is much less frequently the cause of the bleeding. The blood escapes chiefly by the external auditory canal ; but it may also pass down the Eustachian tube, and escape by the nostrils and mouth. It may also, when coming from the sinus, escape by a carious opening behind the auricle. The blood, in some of the cases, spouted out in a pulsating jet, causing death in a few minutes, and in others it oozed out for hours before the fatal termination. In some again there were repeated bleedings at intervals of from a few minutes to several hours, ending in fatal exhaustion.

Treatment. The introduction of astringents, or plugging the external canal, has little or no effect upon the bleeding. Continuous compression of the common carotid, when the hæmorrhage has its source in the internal carotid, should be tried ; and, if everything else fails, the propriety of ligaturing the common carotid should be seriously considered. Hitherto that operation has failed to save life.

CHAPTER XIV.

EXUDATIVE INFLAMMATIONS OF THE MIDDLE EAR WITHOUT PERFORATION.

These include (1) the painful exudations, with pronounced inflammatory changes in the tympanic membrane (acute non-purulent inflammation of the middle ear), and (2) the simple, painless exudations, with but slight inflammatory changes in the tympanic membrane (exudative catarrh of the middle ear).

We shall first take up the painful and more pronounced inflammatory form.

ACUTE NON-PURULENT OR NON-PERFORATIVE INFLAMMATION OF THE MIDDLE EAR.

Syn.—Acute Inflammation of the Middle Ear—Otitis Media Acuta (Politzer); Acute Simple Catarrh (von Troltsch); Acute Catarrhal Inflammation of the Middle Ear (Roosa).

To describe this affection in detail would involve the recapitulation of the description of the *first stage* of purulent inflammation of the middle ear (to which the student is referred at p. 223).

Distinction from Purulent Inflammation. The only distinction is that this form of inflammation does not go on as in the purulent variety to perforation and discharge. If rupture of the membrane takes place, with discharge of purulent or muco-purulent secretion, the case is one of purulent inflammation of the middle ear. While, if the painful symptoms and the inflammatory appearances of the membrane pass away without perforation or discharge, the case is regarded as one of non-purulent inflammation. This distinction carries with it important consequences, and leads to a different prognosis.

The non-purulent form of inflammation, instead of terminating in perforation or discharge, usually subsides in from four days to a week. But a greater or less degree of deafness and a dull, heavy

feeling in the ear may continue, even in favourable cases, for three or four weeks. During this time crackling sounds are sometimes heard in the ear, especially while blowing the nose or swallowing, which are due to the separation of the walls of the Eustachian tube; these sounds are frequently attended by more or less improvement in the hearing. The deafness occasionally passes off completely with a loud crack, described by some patients as being like the report of a pistol; as a rule, however, the improvement of the hearing after such a sound is only temporary.

The Tympanic Membrane assumes, after the acute inflammatory stage passes away, a yellowish grey or sometimes a leaden colour, with, at certain points on its surface, a moist appearance. In the greater number of cases, however, the membrane recovers, in the course of three or four weeks, its normal aspect and polish. As long as any secretion remains in the tympanic cavity, we may find a number of small separate vessels radiating from the centre to the periphery of the membrane (Fig. 212). A somewhat hyperæmic state of the membrane along the manubrium and in the vicinity of the short process is probably the last objective symptom to disappear.

Fig. 212.

Fig. 213.

Fig. 212.—Hyperæmia of tympanic membrane.

Fig. 213.—Saccular bulging projecting from the upper and back part of the left tympanic membrane. *a*, Bulging; *b*, inflamed membrane in front.

Consequences. Acute non-perforative inflammation of the middle ear may lead to permanent swelling and thickening of the mucous membrane with the inspissation of secretion. As the result of repeated attacks of the disease, or even of a single attack, there may be laid the basis of permanent changes in the tympanum and Eustachian tube, changes which will be considered under the heading of *non-exudative inflammation*. In this way deafness, increasing gradually over years, and attended by distressing tinnitus aurium, may have its origin in one or several attacks of this disease.

Prognosis of Acute Non-perforative Inflammation. While the prognosis does not carry with it serious danger to life as in the case of the purulent form of inflammation of the middle ear, there is the risk of the disease leaving behind a damaged tympanum. Owing to its viscid character the secretion may not be readily absorbed without treatment, while, from the greater depth and intensity of the inflammatory process, permanent changes in the mucous membrane are more to be feared than in the simple exudative catarrh. We often find patients tracing their permanent deafness in after years to earache in childhood, no doubt in many cases the expression of non-perforative inflammation which had initiated permanent interstitial changes. The pathological meaning of these

earaches is rarely understood by the physician, and, as a consequence, unseen and unsuspected processes are allowed to pursue their course undisturbed by treatment.

It may be truly affirmed that the cases are few in which improvement cannot be effected by appropriate treatment, while entire recovery is the rule. Only when treatment is imperfect or quite neglected, or where the affection occurs in certain unfavourable states of health, should serious and permanent consequences ensue. The inflammatory process may, in such circumstances, lead (1) to irremediable condensations, contractions, or adhesions in the middle ear: (2) to softening and perforation of the tympanic membrane, with all the possible consequences; or (3) to the development of grave labyrinthine changes.

The Treatment of Acute Non-perforative Inflammation is, in its *early* stage, the same as that of the first stage of purulent inflammation;—local abstraction of blood, warm applications, sedatives, etc. (see p. 243).

When the acute or painful symptoms have passed off, inflation of the middle ear is of great importance in improving the hearing and relieving the subjective sounds as well as the sensations of fulness and numbness in the ear. In the early stage of the inflammation, when the pain is very acute, inflation may aggravate the disease. When, however, the pain has become less severe, but the deafness more marked, owing to the exudation in the cavity of the tympanum, the use of Politzer's method of inflating the middle ear is generally very beneficial both in improving the hearing and in mitigating the unpleasant sensations. At first the pressure upon the air-bag should be moderate: but, as the acute inflammatory symptoms completely pass off, and if no pain is excited by the inflation, a greater amount of pressure may be employed. If the improvement in hearing continue for only a few hours after inflation, Politzer's method should be repeated every day for a few days, and then, when the improvement continues for a longer period, the interval should be extended to two days, and afterwards to three or four days, until complete recovery of the hearing is established. This in most cases will be achieved within four weeks, supposing no disease has previously existed in the ear.

Incision of the Tympanic Membrane is not, as a rule, to be recommended for this form of inflammation except in the very late stages, when a muco-serous exudation may persist in the tympanic cavity after all the acute symptoms have disappeared. In the earlier stage, incision of the membrane is liable to set up a prolonged muco-purulent discharge difficult to cure. At this stage, therefore, incision should only be practised if a distinctly pointing yellowish

bulging presents itself (Fig. 213) along with extremely painful symptoms which do not abate under the treatment already described.

For the treatment of the *secondary changes in the tympanic cavity*, when these are supposed to exist, the student is referred to the treatment of Non-exudative Inflammation at p. 338.

EXUDATIVE CATARRH OF THE MIDDLE EAR.

Syn.—Mucous or Muco-Serous Catarrh of the Middle Ear; Catarrh of the Middle Ear (Politzer); Otitis Media Catarrhalis; Obstruction of the Eustachian Tube.

PATHOLOGY.

In this form of inflammation the hyperæmia and swelling of the mucous membrane are less severe and more superficial than in the acute non-perforative form, while the secretion consists of mucus or serum, or both combined. The catarrhal condition is sometimes limited to the Eustachian tube, either simply at the pharyngeal opening or over the whole of the cartilaginous part. When limited to the Eustachian tube, it is sometimes called tubal catarrh, or "obstruction of the Eustachian tube." The obstruction of the Eustachian tube is apt to be followed by serous exudation in the cavity of the tympanum, owing to the suction upon the vessels of the mucous membrane caused by the rarefaction of the tympanic air (hydrops ex vacuo); even blood may exude from this cause. More frequently, however, the morbid process extends to the lining membrane of the tympanic cavity, and even to the mastoid cells. There is rarely spontaneous perforation of the tympanic membrane; and, if there is, the opening, after giving exit to some mucus or serum, soon heals up, seldom leaving a trace behind.

CAUSES OF EXUDATIVE CATARRH.

This affection is most frequently found in children, when it is, in many cases, *associated with adenoid vegetations in the naso-pharynx.* It often originates in acute or chronic rhinitis. It has probably in many cases a bacterial origin (see p. 57). In some persons a slight form, perhaps confined to the pharyngeal opening of the Eustachian tube, occurs during every cold in the head.

The exanthematous diseases, especially measles, are frequent causes. Children of a strumous diathesis are more liable to it; and it occasionally arises from syphilitic disease of the throat. (See chapter on the Causes of Ear Disease.)

SUBJECTIVE SYMPTOMS.

In the slighter forms, when the catarrhal process is limited to the pharyngeal end of the Eustachian tube, the symptoms complained of by the patient may be no more than a sense of fulness and pressure in the ear with slight impairment of hearing and

tinnitus. He has also usually a sense of crackling when blowing the nose. Patients sometimes speak of a sensation of water dropping in the ear, or of a moving body. Pain is seldom complained of in this affection; occasionally, however, slight *earache* is experienced. In the localized catarrh of the middle ear, which is often connected with a simple "cold in the head," the symptoms generally pass off in a few days.

In more pronounced forms, when the process extends to the tympanic cavity, although the *defect of hearing* is much greater, the sense of *pressure* or *fulness* in the ear may be less marked. If both ears are affected, the deafness may be so considerable, that very loud speaking close to the ear is necessary. The hearing varies, however, in different cases as well as in the same person at different times. These fluctuations, which are often very sudden, may be due either to changes in the Eustachian tube disturbing the tension of the tympanic membrane and ossicular chain, or to changes in the position of the exudation, or in the degree of swelling of the tympanic mucous lining. The deafness is most marked when the exudation or swelling affects the ossicula and fenestral structures. The sudden opening of the tube from subsidence of the swelling of its mucous membrane or from the expulsion of a plug of mucus, is often attended by a crack in the ear, after which the hearing may be much improved for a time. The dulness, however, usually soon returns accompanied by a sensation, which the patient sometimes compares to the shutting of a valve. A *benumbed sensation* over the side of the head and affected ear is often complained of.

The Perception by Bone-conduction is, in uncomplicated cases, markedly increased. If the catarrhal process be limited to one side, the vibrating tuning-fork applied to the median line of the head is heard with much greater intensity in the affected ear than in the normal one. The patient has often the sensation as if the sound were heard only on the deaf side. If the tuning-fork be heard better on the *normal* side, and if a distinctly catarrhal process exist in the other ear, there is probably a concomitant affection of the labyrinth, which will be found in many cases to be of a syphilitic character. The patient sometimes complains very much of the sense of increased resonance of his own voice (autophonia), which has been compared to the sensation felt while speaking with the head in an empty cask (Politzer).

Subjective Sounds in the ear are not at all constant phenomena. Crackling sounds are, however, often heard, particularly on swallowing or blowing the nose, and arise from the passage into the tympanum of air through the Eustachian tube, when its partially agglutinated walls become separated from one another.

Occasionally patients complain of *heaviness*, *confusion*, and *diminished power of mental work*, while sensations of temporary

giddiness are sometimes experienced. The author has in certain cases seen all the phenomena of Ménière's disease associated with it. Children, on the other hand, who have exudative catarrh of the middle ear, are not unfrequently observed to be dull, incapable of mental exertion (aprosexia), disinclined for play, capricious, and ill-humoured.

OBJECTIVE SYMPTOMS OF EXUDATIVE CATARRH.

The appearance of the tympanic membrane varies greatly.

The Indrawn Tympanic Membrane. In cases where the Eustachian tube has been for a time impermeable to the passage of air the position of the membrane is characteristically changed (Fig. 214). By the rarefaction of the air in the tympanic cavity the pressure of the atmosphere on the outer surface of the membrane is no longer counterbalanced by an equal pressure on the inner surface, the result being that the membrane is forced *inwards*, and its outer concavity, especially at the centre, is markedly increased. This change in the curvature of the membrane is shown most clearly by the altered position of the manubrium, which is tilted inwards, upwards, and slightly backwards, and appears perspectively as if shortened. While the handle of the malleus is thus tilted inwards and upwards, the short process projects strongly towards the external canal, frequently resembling a white pointed peg (Fig. 214), and the folds passing from this are rendered more tense and prominent, especially the posterior fold, which may appear like a white projecting ledge or ridge. If the inward bulging of the membrane be extreme, the lower half may present a convex appearance due to the membrane at that part lying in contact with the promontory, while the anterior rounded edge of the entrance to the fenestra rotunda may be seen behind and below. The cone of light is usually absent, but we often find a dark line, like a fine fold, extending parallel with, and a short distance from, the antero-inferior periphery of the membrane. The membrane frequently presents a violet or reddish tint, derived from the reflection of the hyperæmic lining of the tympanum. The long process of the incus and the head of the stapes are frequently seen through the membrane, especially when the latter is pretty thin and transparent at the upper and back part.

Fig. 214.

Fig. 215.

Fig. 214.—Indrawn tympanic membrane caused by obstruction of the Eustachian tube, showing short process of malleus with the indrawn manubrium below; also part of stapes connected with long process of incus—both seen through the membrane lying closely over them.

Fig. 215.—The same tympanic membrane after inflation by Politzer's method.

After Effective Inflation the indrawn membrane, if not bound down by adhesions, etc., undergoes a striking change (Fig. 215). The manubrium and the short process with the folds passing from it return partially or completely to their normal position, and the membrane may even bulge outwards on

each side more than in the natural state, so that the manubrium lies in a furrow. The vessels of the manubrium become for the moment more injected, and the colour of the membrane again becomes distinctly grey, while fine vessels are sometimes perceived radiating from the centre to the circumference, and the parts within the tympanic cavity, which may have been previously visible, now disappear from view.

Fluid Exudation in the Cavity of the Tympanum. Along with this indrawn position of the membrane, although frequently also with a normal state of its curvature, there may be signs of *fluid exudation* in the cavity of the tympanum. If the membrane be fairly transparent, and the exudation only partially occupy the cavity of the tympanum, the presence of this exudation may be clearly shown through the membrane.

A line, sometimes light coloured but generally dark grey or even black, corresponding in position with the upper surface of the exudation (Fig. 216), is seen in favourable circumstances. This line may cross the membrane from side to side, and may be convex, concave, or wavy, or it may extend only over a portion of the membrane, such as from one side of the manubrium to the periphery. Below this line the membrane has usually a darker and sometimes a more yellowish colour than above, from the exudation behind it. If the exudation in the cavity of the tympanum be very thin, this line may change its direction, when the patient's head is moved backwards or forwards, from the change in position of the thin exudation; while, after inflation, a number of small circles, with dark well-defined outlines, may be seen through the membrane (Fig. 217). These are air bubbles produced by the mixing of the air with the exudation, and on inspection of the membrane they may be seen to move briskly during the inflation. After inflation the part of the membrane corresponding with the exudation behind may become more transparent, or, on the other hand, it may become more of a yellowish or bluish grey colour.

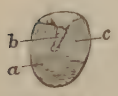

Fig. 216.

Fig. 217.

Fig. 216.—Exudation in cavity of tympanum, seen through transparent tympanic membrane. *a*, Exudation; *b*, middle of manubrium; *c*, membrane in front of manubrium.

Fig. 217.—Air bubbles seen through tympanic membrane immediately after inflation in case of fluid exudation in cavity of tympanum. *a*, Air bubbles.

A well-marked Bulging in the upper and back part of the membrane (Fig. 213) sometimes indicates the presence of exudation. This bulging is most frequently yellowish grey or greenish yellow in colour, more rarely whitish. Probably in these cases the membrane at the bulging part undergoes a softening and thinning process, so that it yields to the pressure of the secretion. The bulging is sometimes found to appear only after inflation of the middle ear. This is particularly the case when exudation exists in the cavity of the tympanum, and a portion of the membrane is atrophied or cicatricial (see p. 218). After inflation, yellowish secretion may be seen behind the atrophied and now bulged part of the membrane.

When there is no Bulging of the Membrane, but rather the

contrary, the signs of exudation are less distinct. If the membrane be not opaque and the exudation be yellowish or wine-coloured, a more or less greenish yellow glitter is seen, and the membrane may have a more *moist shining appearance* than in the normal state. Inflation sometimes helps us in this case to distinguish the existence of the secretion. After inflation the colour may become more yellow, and a bulging may be perceived at some particular part of the membrane, especially behind the umbo, giving at once the impression of a fluid collection.

Fluid Exudation with Unchanged Membrane. If, as is frequently the case, the membrane be not sufficiently transparent to admit of the contents of the tympanum being seen through it, the signs of fluid exudation in that cavity are much less reliable. This insufficient transparency may be normal to the individual, or it may have been caused by the long continuance of the catarrhal process. When the membrane is not completely obscured, illumination with the sun's rays reflected from a flat mirror may help us to make out the presence or absence of exudation in the tympanum. If the membrane be completely opaque, simple inspection will not help us much. When, however, moist crackling is heard by auscultation during inflation, and when there is decided improvement of the hearing immediately after, there is great probability of the existence of exudation. The crucial test, however, if we are in doubt, is to puncture the membrane, an operation which may be performed with almost certain safety.

COURSE AND CONSEQUENCES OF EXUDATIVE CATARRH.

Duration. When the catarrh is due to an acute naso-pharyngeal attack, and limited to the pharyngeal mouth of the tube, the swelling and hypersecretion usually pass off under suitable treatment in from a few days to two weeks, with complete restoration of the hearing. When, on the other hand, the disease is the consequence of *chronic catarrh or adenoid vegetations in the upper pharyngeal cavity*, or when there exists in the individual a catarrhal tendency of the mucous lining of the middle ear, the disease is apt to run a very much more protracted course, and improvement is liable to be interrupted by relapses. The affection may in these cases *go on for years*, especially in childhood, becoming more aggravated during winter and spring, and improving again in warm dry weather. The character of the exudation has also an important influence on the course of the disease. When it is *thin and serous*, its absorption by nature, or its complete removal by operation, is more certain and rapid than when it consists of *viscid stringy mucus*.

Consequences. As the result of exposure to severe cold, microbic infection, or even the irritation caused by mucus in the tympanum, the catarrhal process may assume a *purulent* character.

The catarrh may, however, exist for years without producing more than swelling of the mucous membrane and fluid exudation, an ultimate cure resulting without any injurious after-effects. In other cases changes take place either during the stage of secretion or, more generally, after this stage has passed off. The long-continued indrawn or "sunken" condition of the membrane, due to the impermeability of the Eustachian tube, may lead to important and permanent consequences.

Atrophy of the Tympanic Membrane. The abnormally increased tension leads in time to thinning or *atrophy*, involving a part or even the whole of the membrane. The atrophied part, from being abnormally thin and flaccid, is depressed below the healthy membrane; it is also darker in colour, and its borders are sharply defined from the normal membrane. The interior of the tympanum, opposite the atrophied part, is sometimes seen as distinctly as if nothing intervened (Fig. 218). When we inflate the middle ear, or employ suction with Siegle's speculum, the atrophied part bulges out, sometimes like a small bladder (Fig. 219), but the bulging soon disappears. Even after the Eustachian tube has again become freely permeable the atrophy remains, and while inflation of the middle ear, by Politzer's method or Valsalva's experiment, causes it to bulge out, and temporarily improves the hearing, it is found that in a few hours the atrophied part returns to its sunken position, and the improvement in the hearing at the same time passes away. When there is a very permeable Eustachian tube we may find the atrophied portion *moving with inspiration and expiration*. A slight amount of atrophy, however, is quite compatible with good hearing.

Fig. 218.

Fig. 219.

Fig. 218.—Left tympanic membrane in which there is atrophy, including the postero-superior part; through the transparent atrophied portion is seen, above, the articulation of the incus and stapes; below, the rounded border of the entrance to the fenestra rotunda. The atrophied part lies in contact with these. *a*, Centre of atrophied part of membrane.

Fig. 219.—The same membrane immediately after inflation by Politzer's method, showing the bladder-like bulging of the atrophied portion. *a*, Centre of atrophied part; *b*, short process of malleus.

Adhesions and Retractions. The long-continued indrawn position of the membrane may also lead to its permanent adhesion to the promontory or to the articulation of the incus and stapes, or to permanent retraction of the tendon of the tensor tympani muscle. The retraction of this tendon is brought about in consequence of its slackened condition for a length of time, due to the diminution of the distance between its point of attachment and the inner wall of the tympanum. This slackening induces in course of time a permanent shortening. In this state, when the membrane is forced out by inflation, slight improvement may take place, which is, however, very transient, as the membrane shortly returns to its previously sunken position.

Thickenings and Condensations. In some persons the persistent hyperæmia and swelling lead in time to gradual thickening and condensation of the mucous membrane of the tympanum and Eustachian tube, while the exudation may become gradually inspissated and organized, and adhesions, false bands, etc., form between various parts of the tympanum and between the walls of the Eustachian tube—changes which will be described under the heading of interstitial inflammation. Why in some persons the interstitial exudation in the mucous membrane never changes from the cellular form, while in others it goes on to the new-formation of connective tissue, is not easily understood.

DIAGNOSIS AND PROGNOSIS.

We recognize this affection chiefly by the appearance of the tympanic membrane and *by the effects of inflation.* If we are in doubt, puncture of the membrane with subsequent inflation will demonstrate the presence or absence of fluid exudation in the tympanic cavity. The prospects of complete recovery of the hearing are in most cases very favourable. The prognosis is less favourable: (1) When inflation of the middle ear, or incision of the membrane with evacuation of the secretion, effects little or no improvement in the hearing. In this latter case we may suspect that, in addition to fluid exudation, there is either marked swelling of the mucous membrane or even, what is worse, thickening and condensation, with other irremediable changes in the tympanic structures. If the secretion be *viscid and tough*, the difficulty of recovery is greater. (2) When there is a markedly hereditary tendency to chronic catarrh. (3) When the patient is of unsound constitution, especially if tubercular or syphilitic. (4) When his position in life exposes him to the causes of ear catarrh, or if his habits are such as are unfavourable to health.

For other prognostic considerations, see Prognosis of Non-exudative Inflammation of the Middle Ear at p. 335.

TREATMENT OF EXUDATIVE CATARRH OF THE MIDDLE EAR.

Our main objects should be: (1) To restore the proper tension of the tympanic membrane and ossicular chain; (2) to remove or promote the absorption of the exudation contained in the middle ear; and (3) to remove the swelling and hyperæmia of the mucous membrane. *Treatment of the nasal and pharyngeal mucous membrane* and attention to the general health are important adjuncts to these.

Politzer's Method of Inflating the Middle Ear (see p. 18) is the most effective mode of attaining the *first* object, while it also assists materially in attaining the other two. If the patient cannot come sufficiently often to the surgeon, the treatment by inflation

may be entrusted to him at home, with very careful and sufficient instructions. In order to overcome the resistance offered by plugs of mucus in the Eustachian tube or by the swelling of its walls, two or three compressions of the air-bag are frequently necessary, before we are able effectually to inflate the tympanum. A loud crack is sometimes heard by the patient, when the inflation is successful. Immediately after, the patient usually feels marked relief—not only is there decided improvement in the hearing, but there is a sense of clearness in the head and relief to the fulness in the ear. The improvement in hearing is *sometimes very striking*, so that the patient, who previously could hear loud conversation only when spoken close to the ear, now hears the whispered voice several yards off, or the hearing distance of a watch may be increased from two inches to twenty or thirty inches.

The Duration of the Improvement in Hearing is a guide to the frequency with which we should employ inflation. If the improvement last for only a few hours, it should be performed daily for several days. As the duration of the improvement extends, the intervals may be increased to two, three, four days, etc., until, as shown by the normal hearing, the swelling has subsided, and the secretion become absorbed.

The use of the Catheter is not called for in the great majority of cases, and indeed its employment is usually not desirable in this form of catarrh. Since there is frequently a state of acute catarrh of the nasal passages and pharynx, the contact of the catheter is apt to aggravate this, and thereby to increase the catarrhal condition of the ear. Besides, as a matter of experience, it is found that in this affection Politzer's method generally produces even a greater amount of improvement in the hearing than inflation by the catheter. In some rare cases the catheter may be necessary, but even in these cases one or two applications will suffice to prepare the tubes for effective inflation by Politzer's method.

When the exudation in the middle ear is very thin and serous, a quantity of it may flow into the pharynx immediately after Politzer's air-douche has been applied, especially if during the inflation the patient's head is inclined forwards, downwards, and towards the opposite side.

Incision of the Tympanic Membrane. In a large number of cases inflation of the middle ear, *in conjunction with proper treatment of the nasal and pharyngeal mucous membrane*, will suffice to bring about complete recovery of the organ. In a certain proportion of cases, however, in consequence of the secretion being too abundant or too viscid, it is necessary to make an *opening in the tympanic membrane* in order to ensure the complete removal of the exudation.

For a description of the details of the operation of paracentesis of the tympanic membrane the reader is referred to page 74. We cannot better describe the indications for the operation in this

affection than in the words of Politzer. He says, "I perform paracentesis of the tympanic membrane in those cases where, after the use of the other described methods of treatment for several days, no diminution of the exudation is observed, and where, even when exudation is not proved, the immediate improvement of hearing, which constantly follows the inflation of the tympanum, disappears in great part on the following day or on the second day thereafter. I also frequently perform the operation when, on the first examination, the collected mucus is found to be copious, for, although here a cure may be obtained through inflation alone, the treatment is protracted through several weeks, while by paracentesis a complete recovery is often effected in a few days. The great advantage of this operation, consequently, consists in the shortening of the time the patient requires to be under treatment."

In a large number of cases a single operation will suffice. In all cases Politzer's method of inflating the middle ear must be employed at proper intervals after the operation. It may be necessary to continue the inflation for several weeks. After the mechanical irritation caused by the presence of the exudation has been removed, the secreting process usually stops. It is, on the other hand, occasionally necessary, if after the wound heals the exudative process still goes on, to make a fresh opening in a few days, and this may even in rare cases require to be repeated two or three times.

The Removal of the Exudation, followed by Politzer's Method extending over a considerable time, does not always bring about restoration or even much improvement of the hearing. This is due either—(1) to a continued swollen or softened state of the mucous membrane of the Eustachian tube and tympanum ; (2) to a permanent state of atrophy or flaccidity of the membrane from the long-continued increase of tension ; (3) to thickening, condensation, and rigidity of the mucous membrane, especially of that covering the articulations of the ossicula and the fenestral structures, or (4) to implication of the labyrinth.

The Direct Treatment of the Mucous Membrane of the Eustachian Tube and Tympanum for the reduction of the swelling is much the same as that about to be described for non-exudative inflammation. The best effects are obtained from the use of solutions or vapours alternated with inflation (see p. 71). Solutions are probably to be preferred, and the most suitable are those containing chloride of ammonium, or bicarbonate of sodium (Formulæ 91 and 92). These should as far as possible be limited to the Eustachian tube by simply allowing them to flow into its mouth through a catheter, or by employing the air-bag with gentle pressure. Good effects may be derived from the use of a solution of nitrate of silver in the manner described at p. 132. The treatment of atrophy, retraction of the tendon of the tensor tympani muscle, and the other consequences of exudative catarrh will fall to be considered under the treatment of Non-exudative Inflammation of the Middle Ear.

Nasal and Pharyngeal Treatment is of great importance. In most cases there will be found acute rhinitis, chronic rhinitis, or *adenoid vegetations*. It may be said that, with the discovery of post-nasal adenoid growths and their operative treatment, the prospect of effecting a complete cure in this class of affections has attained a degree of certainty seldom reached in any other region of the body.

General remedies should be employed if the patient be strumous, anæmic, or syphilitic (see Formulæ for General Remedies). For the hygienic treatment the student is referred to p. 103.

CHAPTER XV.

NON-EXUDATIVE OR INTERSTITIAL INFLAMMATION OF THE MIDDLE EAR.

Syn.—Chronic Dry Catarrh; Adhesive Processes in the Middle Ear (Politzer); Proliferous Inflammation of the Middle Ear (Roosa); Chronic Catarrh of the Middle Ear; Sclerosis of the Middle Ear.

The pathological conditions included under this designation constitute a large proportion of cases of deafness. In frequency this disease comes next to purulent inflammation of the middle ear. Out of 1088 cases of ear disease recorded by the writer, 291, or about 27 per cent., were classified under this heading. Generally both ears are affected, although one is usually worse than the other.

PATHOLOGY.

There are two fairly well-marked groups of cases: (1) Those in which the symptoms point to a distinctly catarrhal process; (2) those in which there is an absence of markedly catarrhal symptoms—the term *sclerosis* of the middle ear being applied here.

The Catarrhal Group of Cases. In the *first* group the pathological changes found in the middle ear frequently arise out of non-perforative inflammation, or exudative catarrh. After simple hyperæmic swelling the mucous membrane becomes thickened, owing to new-formation of connective tissue in its interstices, and in many cases becomes the seat of chalky or fatty deposition. The thickened and condensed mucous membrane usually in course of time undergoes a shrinking process. The secretion may also become inspissated and organized, agglutinating the ossicula, and hindering their movement. Adhesions, connecting bands, and pseudo-membranes form, so that parts which are usually separate come to be in contact, and after a time unite. In this way the tympanic membrane may form adhesions with the inner wall of the tympanum or with the incus or stapes; or the crura of the stapes may become firmly adherent to the walls of its recess. The ligaments connecting the ossicles with the walls of the tympanum may, on account of the change in the mucous membrane covering them, become contracted and rigid, and in this way these small bones may be bound down and fixed. The tendons of the tensor tympani and stapedius muscles may also be contracted from the same causes. Further, there are frequently found bands or filaments of connective tissue, connecting and binding various parts of the tympanic walls

and contents: thus the tympanic membrane may be connected with the inner wall of the tympanum, and the ossicles with the walls of the tympanum or with one another. The cartilages and capsules of the joints between the ossicles become in many cases stiffened, rigid, and adherent. The malleo-incudal joint and the connection between the edge of the footpiece of the stirrup-bone and the annular ligament are especially apt to share in this stiffening process, and in the case of the latter osseous union not unfrequently takes place. Exostosis or hyperostosis of the osseous tympanic walls or of the ossicula is also sometimes found.

Effects of these Processes upon the Tympanum. We may have in these various ways: (1) The free space of the tympanum much diminished or even obliterated; (2) the tympanic cavity divided into compartments completely separated from each other by adhesions or connecting bands; (3) the whole chain of bones or individual bones fixed or bound to the walls of the tympanum, or firmly anchylosed to one another, or stiffened by the thickened mucous membrane covering them; (4) the stapes adhering or bound to the walls of its recess, or united immovably to the edge of the fenestra ovalis; (5) the membrane closing the fenestra rotunda, and the annular band of the fenestra ovalis thickened, stiffened, or perhaps ossified or calcified; (6) the tympanic membrane thickened to several times its normal state. *As the result of these pathological changes the conduction of sound through the tympanum to the labyrinth is more or less seriously impeded.*

The whole extent of the mucous membrane lining the walls and contents of the tympanum may be involved, or the morbid process may be limited to one part. The function of the tympanum is most seriously injured, when the ossicular chain, *the annular ligament of the fenestra ovalis*, or the membrane of the fenestra rotunda is the seat of the pathological changes.

The Ventilating Function of the Eustachian Tube is in many cases impaired by thickenings of its mucous membrane, or by adhesions or connecting bands which prevent due separation of the walls of the tube during the act of swallowing, etc. Or the defective opening of the tube may be caused by imperfect action of the two tube muscles—the abductor tubæ and the levator palati—which may have undergone fatty degeneration, or become atrophied or paralyzed. In either case the defective ventilation of the tympanum leads to the indrawn tympanic membrane with its consequences.

The Sclerotic Variety of the Disease. In the *second* group, adhesions, false bands, indrawn membrane, and inspissated secretion are not so frequently found. The changes are more those of thickening, condensation, and loss of elasticity of the mucous membrane, which are frequently *limited to the fenestral structures and recesses*, calcification of the membrane of the fenestra rotunda and of the annular ligament of the fenestra ovalis, anchylosis of the ossicula, especially of the footpiece of the stapes, and exostosis or hyperostosis of the osseous walls of the tympanum or of the ossicula. The Eustachian tube, in this form, is frequently *more permeable* than in the normal state.

Disease of the Labyrinth may become associated with any of these pathological conditions, but it is found to be a more frequent attendant upon the second than upon the more purely catarrhal form. Originating as it may do in the labyrinthine fenestræ, the labyrinth may be partially involved from the beginning.

The condition of the **mastoid cells** is not very well understood; but these

spaces are said to be frequently encroached upon by thickening of their lining membrane or of their osseous walls.

CAUSES OF NON-EXUDATIVE INFLAMMATION.

While we found that exudative catarrh is met with most frequently in youth or childhood, this condition is *most common in adult age*. We often meet with it in the female sex at the period of adolescence. It is found in persons or families otherwise perfectly healthy. In childhood, however, the existence of the scrofulous diathesis seems to favour the development of exudative catarrh into interstitial inflammation. *Hereditary influence* undoubtedly plays an important part in the causation of this disease.

As already stated, the more distinctly catarrhal forms of the disease may originate in acute non-perforative inflammation or in exudative catarrh, particularly after *repeated attacks* of these affections. No doubt neglect of treatment is sometimes responsible for this. Just as we found in the other inflammatory diseases of the middle ear, the *fons et origo* of the mischief is often in *the nasal and pharyngeal mucous membrane*. In a large number of cases it will be found that the person is liable to "cold in the head," and that he attributes the beginning of the disease to this cause. He also frequently suffers from some form of chronic rhinitis. In persons predisposed to the disease injudicious cold water bathing is apt to induce it. A rheumatic origin has been attributed to those cases associated with anchylosis of the ossicles.

Syphilis may give rise to this affection, and, in this case, its course is usually very rapid; marked and hopeless deafness, with labyrinthine complication, frequently resulting.

Paresis, atrophy, or fatty degeneration of the muscles of the Eustachian tube and soft palate may excite or at least aggravate the disease. Diphtheria, anæmia, tuberculosis, or indeed any debilitated state of the constitution may impair the functional activity of these muscles. The student is referred to the chapter on the Causes of Ear Disease for further details (see p. 51).

SUBJECTIVE SYMPTOMS OF NON-EXUDATIVE INFLAMMATION OF THE MIDDLE EAR.

The symptoms complained of most frequently are *defective hearing and subjective sounds in the ear.*

The Degree of the Deafness varies very much in different cases and at different stages of the same case. This is chiefly due to variation in the seat of the pathological changes; for instance, the deafness is very marked in fixation of the stapes along with thickening and rigidity of the membrane of the fenestra rotunda; if the

labyrinth also become diseased, the deafness may be almost complete. The defect of hearing is frequently very insidious in its origin, as well as slow and gradual in its progress. If the morbid changes be confined to one ear, the patient may, for a considerable time, be *quite unconscious* of any impairment of hearing, and the disease may exist for a long time, even in both ears, without materially disturbing him either in his social or business relationships: besides, the patient is unwilling to admit the existence of defective hearing at all, even after it has become very apparent to his friends. Hence in our inquiries it is often very difficult or impossible to ascertain when the dulness of hearing began.

Deafness liable to Fluctuation. The degree of deafness, especially in the catarrhal forms, is liable to fluctuation, although not in so marked a way as in exudative catarrh. It is usually aggravated for the time by cold, moist, and dull states of the atmosphere, which influence injuriously the mucous membrane of the Eustachian tube; but extreme heat may also act unfavourably. It is to be remembered that, when the mucous membrane of the Eustachian tube is in a state of permanent swelling or thickening, a very slight additional swelling, say from a "cold in the head," will have a more important effect on the hearing than in the case of a previously normal Eustachian tube. In these conditions, crackling sounds, occasionally followed by transient improvement in the hearing, are sometimes heard by the patient. The deafness is also often aggravated by bodily and mental fatigue, by indisposition, by strong emotion, by much speaking, *during the mastication of food*, by alcoholic stimulants, by excessive smoking, by the use of quinine or salicin, and by hot, close apartments. In these cases the aggravation is probably due either to a change in the condition of the Eustachian tube, or to a change in the perceptive power of the auditory nerve. If the deafness does not fluctuate, but remains the same or *slowly progresses* in severity, the pathological changes probably belong to the second group.

Anomalies of Hearing. The phenomenon of *paracusis Willisii*, or hearing better in a noise, is not unfrequently observed (see p. 38).

A want of proportion between the power of hearing simple tones, such as the tick of a watch, and speech is also found occasionally to exist (see p. 36). Politzer believes that when a tone, such as the tick of a watch, is heard better in proportion than speech, there is rigidity of the ossicular chain, while the membrane of the fenestra rotunda is normal, the sound waves in such a case reaching the labyrinth through the latter channel.

Deafness for *speech* is most marked, and musical tones are usually heard quite distinctly, except when the deafness is extreme.

A somewhat remarkable phenomenon is sometimes observed, both

in the earlier and in the later stages of the disease, namely, painful impressions produced by sounds, the so-called *hyperæsthesia acoustica* (see p. 38). On account of this peculiarity such patients cannot tolerate loud speaking or the use of a hearing trumpet.

Osseous Conduction. The perception of sound by osseous conduction is usually *increased*. In cases, however, which have been obstinate and long continued, and especially when attended by great noises in the ear, osseous perception may be much *diminished*. This is apt to be the case when the disease is complicated with syphilis, or when the patient works amid noisy surroundings.

Subjective Sounds in the Ear. Next to defective hearing the most important and common symptom complained of by the patient is some form and degree of subjective sounds in the ear—*tinnitus aurium* (see p. 369). A very large number of persons, who have this disease, suffer from these sounds, although many say they get "used to them." Children seldom speak of them, although they may be present. The subjective sounds are sometimes complained of *before any deafness is experienced*, it may be for years, especially in *gradual anchylosis of the stapes*; at other times the deafness and the noises in the ear come on simultaneously, while in many cases the "tinnitus" comes on some time after the impairment of hearing has been noticed. The descriptions given by patients of the character of these sounds are very varied. They may be likened to the humming of a shell, the buzzing of bees, steam escaping from a pipe, the sound of a waterfall, the singing of a kettle, water falling into the fire, etc. (see p. 369). In many cases these sounds are much more annoying than the deafness, the patient asserting in earnest tones that he could get on in spite of the deafness, but that the noises in the ear are most distracting, and a terrible affliction. They often become more aggravated as the deafness increases, until the patient may come to the sad position of being shut out from all external sounds, while he is tormented with intolerable noises within the head. At other times, when the insensibility to external sounds has become almost complete, the subjective noises in the ear fortunately disappear, probably owing to complete paralysis of the nerve of hearing. They are generally worse in the evening, and in the house, as compared with the free, open air; while in a quiet room they are heard much more loudly than amid the noise and engrossment of business, when for the time they may not be perceived at all. The causes, which have been mentioned as increasing the deafness (see p. 328), usually also aggravate the tinnitus aurium.

Painful Sensations in the Ear or Head. While *pain* is seldom complained of, a sense of fulness, pressure, or "stopping up" in the ear is not unfrequently spoken of by patients. Some patients get into the habit of frequently *sniffing*, which seems to relieve them for the

moment. It may be difficult to convince a patient that there is not an actual obstruction in the canal of the ear which should be easily removed. Patients are also in some cases much disturbed by a sensation of crackling or friction in the ear during swallowing. When actual pain is experienced, it is generally due to dental irritation or to neuralgia of the tympanic plexus.

Some patients suffer from a sense of pressure in the head, and others from dull pain over the frontal sinus. Localized pain in the head, which is usually regarded as neuralgia, is also occasionally complained of. This is probably of a reflex character, due to the irritation of the mucous lining of the middle ear transmitted, chiefly through the branches of the trigeminus, to the nerves of the head, just as we find in pain due to dental irritation.

Giddiness, either temporary or permanent, sometimes along with sickness and vomiting—symptoms often attributed to disease of the brain or nervous system—is not unfrequently met with. In these cases the deafness and noises in the head have usually been very marked. This group of symptoms, namely, deafness, noises in the head, giddiness or unsteadiness of gait, and sickness or vomiting, is generally termed Ménière's disease. While these symptoms, when arising suddenly, are often due to a pathological change in the semicircular canals, they may also undoubtedly be excited by pressure upon the labyrinthine fluid from the direction of the tympanum, such as may be produced by the pathological conditions found in this affection (see Ear Giddiness, p. 45).

Mental and Nervous Disturbance, such as diminished power for mental work with depression of spirits, seems occasionally to be connected with these chronic processes in the ear. Patients assert that an amount of mental work, which they could at one time perform with ease, has now become impossible. These symptoms, indicative of disturbance of the central parts of the nervous system, probably occur in persons whose nerve force or resisting power either is naturally weak, or has been impaired by causes acting on the system independently of the ear disease. Probably also the *distracting influences of the noises in the ear* may have something to do with the restlessness and inability to engage in mental work. It is to be noted that these phenomena are met with not only in nervous females but also in men of strong will.

OBJECTIVE SYMPTOMS OF NON-EXUDATIVE INFLAMMATION.

Before describing the changes found in the tympanic membrane, it must be observed that we cannot, in any given case, determine the extent of the deafness from the appearance of the membrane. While in some cases of extreme deafness, due to this affection, *the membrane*

is almost normal in appearance, there are others in which the hearing is only slightly impaired, although the membrane presents *marked abnormality*, such as retraction, atrophy, opacity, or calcareous deposit. In the former case probably the fenestral structures are the seat of the pathological changes, while in the latter the morbid changes are limited to the tympanic membrane. The condition of the membrane is nevertheless to be carefully studied, as its appearance not unfrequently throws light upon the diagnosis and prognosis.

The Indrawn and Adherent Tympanic Membrane. A change in the position of the membrane similar to the "indrawn" or "sunken" condition, described at p. 317, is very frequently observed (Fig. 220). While in exudative catarrh inflation is usually sufficient to force out the membrane, and restore it to its natural position, we find that in this form of inflammation it becomes in many cases so fixed and immovable, owing to stiffening or to organized adhesions between it and the inner wall of the tympanum or incus and stapes, that neither

Fig. 220.

Fig. 221.

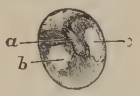

Fig. 222.

Fig. 223.

Fig. 220.—Indrawn tympanic membrane caused by obstruction of the Eustachian tube, showing the short process of the malleus with the indrawn manubrium below; also part of the stapes connected with long process of incus—both seen through the membrane lying closely over them.

Fig. 221.—Left tympanic membrane very much "sunken," and showing the white ring at the periphery. *a*, Middle of manubrium, which is very much drawn in; *b*, white ring.

Fig. 222.—Left tympanic membrane, having patches of calcareous deposition. *a*, Middle of manubrium; *b*, calcareous deposit in front of manubrium; *c*, deposit behind manubrium.

Fig. 223.—Left tympanic membrane, showing calcareous patch having a horse-shoe shape. *a*, Manubrium; *b*, calcareous patch.

inflation nor suction with Siegle's apparatus is capable of restoring the proper curvature. Localized or limited indrawings of the membrane, due to adhesions or bands, are also met with. In front of the upper part of the manubrium, for example, the membrane is in many cases distinctly sunken, imparting an unusual sharpness and depth to this part of the manubrium. Behind the upper part of the manubrium depressions are frequently seen, the depressed portion of the membrane probably adhering to the long process of the incus and the head and posterior crus of the stapes. Pittings of the membrana flaccida are also not unfrequent. A depression, sometimes of considerable size, behind and below the umbo, is occasionally present, and is due to adhesion of a portion of the membrane to the promontory. It is to be remembered that an indrawn membrane and even anomalies of tension are in some cases *compatible with normal hearing.*

The Normal Lustre of the outer surface of the tympanic membrane is frequently retained, owing to the epidermic layer being in many

cases unaffected, and hence the manubrium is generally seen distinctly through the transparent dermoid layer. If, however, the dermoid layer be thickened and dull, the general polish as well as the cone of light may be altogether absent, while the manubrium may either be very indistinctly seen or quite invisible. The *cone of light* is affected by change in the curvature of the membrane, especially in the indrawn membrane. It may in that case become divided into several parts, or extremely narrow or irregular at its edges, or it may be reduced to a point.

The Colour of the Membrane is frequently found changed either in its whole extent or at circumscribed parts. Instead of a general pearly grey colour it is often a whitish grey or even quite white like opal glass. More rarely it has a general leaden grey or yellowish grey tint. *Local* changes of colour are still more frequently observed. A whitish ring, of variable breadth, is fairly often seen round the periphery of the membrane (Fig. 221). This is looked upon by some as analogous with the *arcus senilis* in the eye, but it is also met with in young persons. Behind the upper part of the manubrium a whitish stripe, extending backwards, is sometimes seen, which is probably due to adhesion of the leaf of the posterior pouch of the membrane to the membrane itself. White thickened bands may also be found extending from the umbo to the lower part of the periphery of the membrane. But the most frequent form of greyish white opacity is found in the posterior half of the membrane. This opacity has usually a semilunar shape, with the concavity forwards, but having an irregular edge. When the mucous membrane lining the inner wall of the tympanum is hyperæmic and the membrane lies close to it, the latter presents, especially in its lower half, a *reddish tinge.*

Calcareous Deposit. In the posterior half of the membrane there is not unfrequently a very well marked white or yellowish white appearance, frequently of a semilunar shape with the concavity forwards and *sharply demarcated* from the neighbouring parts of the membrane. It is due to a calcareous deposition in the layers of the membrane (Fig. 222). A similar deposition but more oval in shape is less frequently seen in front of the manubrium. This sometimes unites below with a deposition behind, when a calcareous patch is formed having a horse-shoe shape (Fig. 223). Calcareous deposition in the tympanic membrane is most frequently met with in connection with chronic purulent disease of the middle ear (see p. 232), although it is not rare in the affection we are now considering.

Thickening of the Membrane is often present in addition to whiteness or opacity. This is generally in the inner or

mucous layer, which may become three or four times thicker than normal.

Atrophy. But instead of being thickened, the membrane is not unfrequently *thinned or atrophied* owing in many cases to the prolonged tension from long-existing impermeability of the Eustachian tube (see p. 320). Sometimes a part of the membrane is atrophied, while the rest is thickened.

In the Sclerotic Form the membrane is much less altered than in the more strictly catarrhal form. In the former there is frequently no change in the curvature of the membrane. The lustre or colour may likewise be but little altered—sometimes a slight increase of greyness is seen at the peripheral parts or a yellowish grey in the posterior part. The manubrium and short process may appear smaller; the manubrium being at the same time thinner, sharper, and whiter. Its edge has at times also a nodulated appearance. The membrana flaccida is in many cases much smaller than in the normal state.

Condition of Eustachian Tube. Auscultation during inflation frequently gives evidence of *obstruction of the Eustachian tube.* But it is to be noted that the auscultation sound may be full, clear, and blowing, *indicating a wide tube,* although great deafness may exist from chronic processes in the tympanum. In such cases either the earlier thickening of the mucous membrane of the tube has given place to atrophy with abnormal width of the canal, especially at the isthmus, or the catarrhal process has been from the beginning almost confined to the tympanum, the Eustachian tube having been but little affected. Patients are not unfrequently met with in whom there is in the one ear extreme and long-standing deafness with great permeability of the tube, while in the other there is more recent deafness with the signs of obstruction of the Eustachian tube. It will usually be found that the ear with the obstructed Eustachian tube is much more amenable to treatment than the other.

In the External Meatus we may find a tendency in some cases to excess of cerumen with impaction—such a tendency is occasionally a precursor of the middle ear disease. In the sclerotic variety, we may find, on the other hand, an entire absence of ceruminous secretion, with a wide dry meatus.

COURSE AND CONSEQUENCES.

Slow Course. In the great majority of cases the pathological changes in the middle ear advance, often *slowly and gradually,* with increase in the deafness and tinnitus. The adhesions become stronger, the thickening and contraction of the mucous membrane increase, calcification and ossification may take place, while ultimately, in many cases, the labyrinth shares in the morbid process. The defect of

hearing sometimes remains stationary for many years, and then becomes gradually or rapidly worse. If the labyrinth remain intact the deafness can never be *total*, although the pathological processes in the middle ear may be so far advanced as to result in complete fixation of the stapes. Subjective sounds in the ear may be complained of for a long time before the hearing becomes impaired, especially in fenestral deafness. After the hearing of one ear has become very seriously impaired, *the other ear usually begins to be affected*, and it is not unfrequently found that the second ear, before long, becomes more seriously involved than the first, the patient remarking that the ear which was first affected, and the hearing of which he supposed to have been totally gone, is now the only one with which he hears anything at all.

Rapid Course. Much less frequently the disease pursues a rapid course, the hearing becoming rapidly and seriously damaged in a few months, probably without much alteration in the condition of the tympanic membrane and Eustachian tube. Here the process probably begins in the fenestral structures, and then extends inwards to the interior of the labyrinth. In a *syphilitic patient* the course of the disease is usually very unfavourable, the deafness and noises in the head becoming rapidly worse. Sudden and loud noises, such as the report of a gun unexpectedly in the neighbourhood, as well as injuries to the head, are not unfrequently followed by marked aggravation in the symptoms.

Temporary Aggravations. The condition is often more or less aggravated by an attack of exudative catarrh, acute non-perforative inflammation, or acute purulent inflammation of the middle ear. After these complications have passed away the hearing power may return to its previous condition, but it is sometimes left rather worse than before. Some rare cases are reported of actual improvement in the hearing resulting from an acute purulent process. Spontaneous and permanent improvement is very rare.

Patients suffering from this affection in one ear have frequently some other affection in the opposite ear. This may be purulent inflammation, exudative catarrh, or impacted cerumen. The ceruminous secretion is not unfrequently excessive in quantity and abnormally dry. In other cases, especially in the sclerotic form, there is deficiency of this secretion.

DIAGNOSIS OF NON-EXUDATIVE INFLAMMATION OF THE MIDDLE EAR.

The diagnosis is generally easy, and is based upon the history, the examination of the tympanic membrane and the Eustachian tube, the character of the subjective symptoms and the *effects of treatment*

especially of inflation. An important point in the diagnosis is to distinguish disease in the labyrinth or auditory nerve from disease in the conducting structures, especially when the tympanic membrane and the Eustachian tube are found to be normal. This is considered fully in the section on Bone-Conduction (see p. 39).

Adhesions, Atrophy, or Anomalies of Tension of the tympanic membrane and ossicular chain are usually made out by means of Siegle's speculum, or by inflation of the middle ear during inspection. The immobility of an adherent portion of membrane and the great mobility of an atrophied portion (see p. 320), during the alternate condensation and rarefaction of the air in the external meatus, usually point out pretty clearly the presence of these conditions. If there be excessive mobility of the membrane, there is defective tension; on the other hand, if the mobility be very slight, there is probably undue tension.

Stiffening, Rigidity, or Anchylosis of the ossicles cannot always be ascertained with certainty. Complete absence of movement of the manubrium during the use of Siegle's speculum or during inflation is presumptive evidence either of rigidity of the whole chain or of the malleo-incudal joint. If speech be not heard through a hearing-tube inserted into the external auditory canal, while it is heard when very loud, if spoken close to the head without a hearing-tube, we may assume anchylosis of the ossicula. When words, spoken into a hearing-tube, connected to the outer end of a catheter introduced into the Eustachian tube, are heard, the presumption is that the stapes is movable, while the malleus and incus are rigid. Further, when the labyrinth is proved to be intact, and yet *no improvement follows repeated inflation*, there is probably a stiff immovable condition of the whole or some part of the ossicular chain.

PROGNOSIS OF NON-EXUDATIVE INFLAMMATION OF THE MIDDLE EAR.

The question as to what will be the probable course of this disease in any particular case is fraught with intense interest and importance to the patient.

Complete Recovery as a rule Impossible. When it is considered that this small region, enclosed in great part by unyielding bones, is occupied by structures, the delicacy of whose vibrating power is of paramount importance for the due performance of the function of hearing, and that the processes in this affection lead to stiffening, rigidity, and immobility of these parts, we cannot escape the conviction that after a time complete structural and functional restoration is impossible. This lapse of time has, unfortunately, usually taken place before treatment is asked for or resorted to. The painless course of the disease and the at first almost imperceptible and extremely gradual loss of hearing explain why the patient rarely comes for advice until the pathological processes have gone on for one year, five

years, or even ten years. It is then frequently found that the hearing of one ear is extremely defective, while that of the other is gradually failing.

The surgeon is therefore unfortunately always compelled to explain to the patient that complete restoration of the hearing is not possible. We are thus limited to the consideration of the question, will the hearing become gradually worse, or will it remain as it is, or may it improve? It must be admitted that it is not always possible to decide, from the history and symptoms of a given case, which of these three courses will be taken by the disease.

Importance of Objective Symptoms. It may be said broadly, that in any given case, the more marked the objective changes found in the ear the more favourable are the prospects of improvement. If we find manifest signs of catarrhal or inflammatory changes in the middle ear—an indrawn membrane, a prominent posterior fold, an obstructed Eustachian tube, an atrophied membrane; if nasal stenosis, post-nasal catarrh, or adenoid vegetations be present; and especially if, by a single efficient inflation with the catheter or Politzer's method, a measure of improvement in the hearing, or a diminution in the intensity of the subjective sounds be produced, we may reasonably hope to check or hinder the further development of the stiffening and adhesive processes. If, on the other hand, in a case presenting marked defect of hearing and violent subjective sounds, originating imperceptibly and progressing rapidly, we find no abnormal change in the tympanic membrane; if the naso-pharynx and nasal passages exhibit neither catarrhal nor hypertrophic change; if the Eustachian tube be freely permeable, and especially *if no improvement in hearing* be produced by a single successful inflation, the likelihood is that very little good will be effected by treatment. The fenestral structures and the ossicular joints are probably permanently stiffened.

Information from Results of Inflation. The fact has been emphasized that the absence of improvement, or the temporary aggravation in the deafness after a single act of inflation, must be looked upon as, in most cases, an unfavourable omen. This is especially so if the air passes through the Eustachian tube into the cavity of the tympanum with a full clear sound, showing an open, if not abnormally open, Eustachian tube, and yet no improvement in the hearing follows. In cases, on the other hand, where the air enters the tympanum freely, yielding a thin, shrill, intermittent sound, with a slight improvement in hearing, we may feel more hopeful of doing good than in the previous case. By a course of inflation, we may reasonably hope to overcome, in some measure, the adhesive and stiffening processes, if these are not so complete as to resist entirely the mechanical effect of repeated acts of inflation. It is, however, unsafe hastily to assume, in all cases where a negative result from inflation is found, that no good will be achieved by a course of treatment. Especially when the mucous membrane of the nasal passages or naso-pharynx is the seat of a catarrhal or hypertrophic process, real and permanent improvement has sometimes followed treatment.

The Test of Treatment. It is rarely, indeed, whatever the pathological conditions found or supposed to exist, that we are justified in definitely excluding the possibility of doing good until we have applied the test of treatment. We

must be careful, however, not to push this experimental treatment too far; we must watch closely that no increase in the deafness, or in the subjective sounds, is produced by it; and that on the first indication of such an untoward result the experimental efforts are immediately discontinued.

Exudative Element superadded to the Interstitial. In the mixed class of cases where the exudative form of inflammation is superadded to an already existing interstitial form, the prognosis is undoubtedly much more favourable. A patient who has been dull of hearing for many years becomes suddenly worse. This will frequently be found to be due to a more recent process of an exudative nature being added to a previous interstitial affection. Immediate improvement generally follows inflation in such cases, and we are able to relieve the anxieties of the patient, and promise at least a return to the previous condition.

When Associated with Labyrinthine Disturbance. In the class of cases supposed to be associated with labyrinthine disturbance, the facts yielded by tests applied to determine the state of the bone-conduction of sound in relation to the air-conduction are of considerable importance. While there is no doubt that excess of bone-conduction, as tested both by Weber's and Rinne's tests, should be regarded as a favourable point in the prognosis, it is by no means a reliable indication that treatment will prove useful. That incurable stiffening of the ossicles may be attended by relative excess of bone-conduction is a familiar clinical fact. In like manner, where the bone-conduction is found to be relatively weak, we must not hastily give an absolutely unfavourable prognosis. This refers not only to persons over sixty years of age in whom, as we know, weak conduction by the bone is usual, but to patients in early and middle life, where, notwithstanding the existence of relatively weak bone-conduction, improvement sometimes follows a course of treatment. There are no doubt many cases of middle ear inflammation associated at the same time with a nerve or labyrinthine affection, it may be temporary in character, in which the latter neutralizes, or more than neutralizes the tendency to excess of bone-conduction excited by the former. In such cases the treatment of the inflammatory element in the middle ear, or of the labyrinthine disturbance, may lead to appreciable improvement. Still it must be admitted that weak bone-conduction has usually a sinister meaning, and nearly always implies, even in the exudative form, that no more than partial improvement need be expected from treatment. Weak bone-conduction bears the worst meaning in cases of non-exudative otitis media in children where repeated inflation produces no impression upon the hearing. In regard, therefore, to the significance of excessive or defective bone-conduction, caution should be exercised in giving a categorical opinion simply upon such a basis. The other features of the case, both subjective and objective, which have been already adverted to, must at the same time be carefully considered.

The Significance of Hearing better in a Noise. This anomaly of hearing is present in a considerable number of the non-exudative cases of otitis media, and it is now generally admitted that its presence indicates a degree of stiffening of the conducting structures. In so far as this is the case, it is generally regarded as unfavourable from a prognostic point of view. It must not be regarded, however, as necessarily excluding all chance of improvement. As a matter of fact, improvement does occasionally follow the judicious treatment of cases associated with this phenomenon.

The Bearing of Defective States of Health upon Prognosis. The tendency to the development of permanent changes is greater in unsound constitutions, especially in the tuberculous, scrofulous or anæmic conditions, or when there is a marked hereditary tendency to middle ear disease or nasal catarrh. When the patient's mode of life is such as to be unfavourable to health or such as to expose him to the usual causes of middle ear inflammation, there is a greater tendency to persistence or recurrence of the disease. The exanthematous diseases, especially measles and scarlet fever, often impress upon the inflammation a tendency to the development of permanent changes in the tympanum. Syphilis seems to engraft upon these cases a serious character. In cases of non-exudative otitis media which have been quiescent for a considerable time one often sees a rapid change for the worse, due to involvement of the labyrinth, after the reception into the system of this virus. So when the disease occurs in a constitution already infected with syphilis, the prognosis must be regarded as much less favourable, owing to the greater tendency to labyrinthine complication, with defective bone-conduction.

Statistical Statements, published from time to time by various authors, professing to show the percentage of improvements or cures, do not throw much light upon the prognosis of this affection. We have not yet at our command sufficiently reliable information in the form of statistics as to the results of treatment.

TREATMENT OF NON-EXUDATIVE INFLAMMATION OF THE MIDDLE EAR.

The treatment may be divided into three parts: (1) the local treatment of the ear; (2) the treatment of the nasal and pharyngeal mucous membrane; and (3) the constitutional treatment.

(1) **Local Treatment.** This aims at (*a*) restoring the proper tension of the tympanic membrane and ossicular chain: and (*b*) counteracting the adhesive, thickening, and contracting processes, which are going on in the middle ear.

Inflation of the Middle Ear. The most important means of attaining these objects is inflation of the middle ear, either with the catheter, or by Politzer's method, or both combined. For the explanation of the therapeutic value of inflation of the middle ear and the comparative merits of catheterization and Politzerization, the reader is referred to the chapter on Methods of Treatment (p. 63). In many cases Politzer's method does best, while in others the best results are attained by the combined use of the catheter and of Politzer's method. When the Eustachian tube is considerably obstructed, and the tympanic membrane markedly sunken and thickened, the use of the catheter, at intervals of three days for from four to six weeks, may be required. If there be great resistance to the entrance of air into the cavity of the tympanum, as shown by the character of the auscultation sound and by the fixed position of the membrane, five or six strong compressions of the air-bag at each

sitting are essential. On the other hand, if the tube be freely permeable, or the membrane atrophied, the compression should be very moderate. After catheterization has been carried on for that period of time, it is usually desirable to continue inflation by Politzer's method for a month longer. This method should be employed every second day, and in some cases daily. As a rule the patient will be quite able, after proper instruction, to carry it out at home. Sometimes *Politzer's method alone* is more effective in improving the hearing and relieving the subjective noises than the use of the catheter.

Effects of Inflation. By either method, the therapeutic effects are never so striking nor so lasting as in exudative catarrh. A temporary slight aggravation may even be caused by inflation, due to the excessive tension of the tympanic membrane, which, however, soon passes off, especially after swallowing. The best effects are obtained when the mucous membrane has still a certain degree of softness and flexibility, and when the tympanic membrane is not fixed immovably in an abnormal position, or the ossicula have not become completely rigid. The improvement in the hearing or in the noises in the ear, which may follow inflation, is generally at first transient; in atrophy of the membrane or retraction of the tendon of the tensor tympani the duration of the improvement may not exceed a few minutes. The parts stretched out by the mechanical effects of the inflation soon shrink or fall back again. When improvement in hearing, lasting one or two days, follows each of the first few inflations, the ultimate result of treatment is likely to be much more favourable than in cases where no improvement follows the first few inflations. If treatment by inflation seems to increase the subjective sounds or the defective hearing (unless very temporarily) *it should at once be stopped.*

Valsalva's Method. Save in exceptional cases treatment by Valsalva's method is to be deprecated. The temporary improvement which sometimes follows is dearly bought at the cost of injury to the hearing through its frequent repetition (see p. 65).

Application of Solutions to the Interior of the Middle Ear. The therapeutic effects of inflation may be augmented or assisted by the application to the middle ear of medicated solutions. They are more likely to prove useful when there is simple swelling of the mucous membrane of the middle ear due rather to round-celled infiltration than to interstitial formation of connective tissue. In addition to a 1 per cent. solution of such substances as bicarbonate of sodium, chloride of ammonium, and iodide of potassium (the latter specially when the disease is connected with syphilis), Delstanche has recently reported great benefit from the forcible injection of sterilized

oil of vaseline, which he says leads in many cases to the separation of adhesions and improvement in hearing. The use of menthol dissolved in paroleine has also been recommended. The injection of a few drops of a 2 per cent. solution of pilocarpine is recommended by Politzer. For further information regarding the employment of solutions for the middle ear and the method of application, see p. 71. In the use of solutions it is well to employ them alternately with inflation by Politzer's method, or by catheterization, at intervals of two or three days for several weeks.

The vapour of ether, chloroform, chloride of ammonium, turpentine, menthol, eucalyptus, or iodide of ethyl may be tried in the manner described at p. 73, where also the value of vapours applied to the middle ear is indicated.

Special treatment of Constriction of the Eustachian Tubes. When we suspect great swelling of the lining membrane of the Eustachian tube, stricture by adhesions or thickenings, neither inflation nor the introduction of vapours or solutions may be possible. In these cases cautious attempts may be made (only by the experienced aural surgeon) to reduce the great swelling of the mucous membrane with strongly stimulating substances, or to dilate the canal by mechanical means. When the mucous membrane is simply swollen it is recommended by Politzer to introduce through the catheter as far as the isthmus tubæ, for a few seconds, a violin string or catgut bougie, the end of which to the extent of two inches has been previously dipped in a saturated solution of nitrate of silver or sulphate of copper, and then allowed to dry. It is asserted that if this be employed every third day for three or four times, the swelling of the mucous membrane of the Eustachian tube may be reduced to such an extent as to allow of effective inflation by Politzer's method.

Eustachian Bougies. When such local treatment fails in opening the canal sufficiently to allow of a stream of air passing into the tympanic cavity, the experienced surgeon is justified in attempting gradual mechanical dilatation by means of thin gum bougies (Mathieu, Paris) with olive-shaped, conical or cylindrical points which, before use, may be dipped in liquid vaseline or other medicated substance. A series is required ranging from a half to one millimetre in diameter. An olive-shaped one is the most useful in overcoming a stricture. Bougies are introduced through a catheter, which is better to be short and to have an acutely curved beak. The point of the bougie should be introduced as far as the tympanic end of the Eustachian tube, the length of which is an inch and a half. The length of the catheter should be marked off with ink on the bougie, so that when the latter is passed into the catheter (properly introduced into the Eustachian tube) we may know from the ink-mark when the point of the bougie has reached the inner end of the catheter. A second mark is made an inch and a half from the other, visible when the bougie is introduced, which informs the operator how far into the Eustachian tube the point of the bougie has at any moment reached. The bougie should remain in position for from five to ten minutes. It should be cautiously and slowly introduced. Difficulty in passing a bougie may not be due to constriction but to folds of the mucous membrane. Several efforts at different times may be necessary before its complete introduction is possible. Air afterwards enters the tympanic cavity by the catheter more fully and freely, and there

is often relief to the deafness and subjective sounds. If its action prove favourable the bougie may be introduced twice a week for several weeks.

Value of Bougies. On the whole, efforts to dilate the Eustachian tube by mechanical means are attended by success in a fair proportion of cases, although frequently, owing to the character of the stricture, it is quite impossible to dilate it; while, even in cases where complete dilatation has been achieved, improvement does not always take place in the hearing or in the subjective sounds in the ears. This method should be employed when there is evidence of a marked stricture or narrowing of the Eustachian tube, and where other methods have been tried without success. Urbantschitsch has found benefit from introducing a bougie into a Eustachian tube *when no stricture exists*, and employing slight frictional movement.

Electrolysis has been proposed in stricture of the Eustachian tube, but its value has not yet been established.

Rarefaction of the Air in the External Meatus is sometimes of service, especially in cases associated with great noises in the ear. The conditions in which this method of treatment does most good are those associated with great retraction of the membrane from adhesions, etc. The methods of employing it are described at p. 77. A more beneficial influence is secured by employing inflation of the middle ear before the process of suction. Where gentle suction relieves, the patient may, as in inflation, employ it at home with the air-bag and proper ear-piece. Patients often seem to find relief from rapidly repeated pressure on the tragus or external meatus with the finger. Bing uses an aspirator furnished with a valve for prolonging and intensifying the air exhaustion. The gradual method of suction (see p. 77) is said by Politzer to afford more enduring though less rapid improvement. It has to be confessed, however, that this method of treatment is frequently ineffectual in relieving the patient. In some there is improvement in the hearing and relief of the sounds in the ear; this improvement is, unfortunately, in many cases but temporary, lasting merely for a short time after the suction process.

Some patients are found to be frequently *sniffing*, even when they are themselves unconscious of the fact. The author has observed that such persons have usually an unduly flaccid membrane with an abnormally patent Eustachian tube, and that the act of sniffing gives relief to a sensation of fulness in the ear which they often experience. The sensation is caused by currents of condensed air passing up the tube and pressing out the membrane; this is relieved by the suction of air from the middle ear which takes place in sniffing.

Collodion. M'Keown advocates the application of collodion to the outer surface of the tympanic membrane when the membrane is flaccid, or where adhesions exist. He claims for collodion applied in this way that, by firming and exercising traction upon the membrane, it tends to prevent or destroy adhesions, and replace the membrane in its normal position.

The feathered sound of Lucæ was recommended by him for applying to the short process of the malleus and pressing it repeatedly inwards. It is a painful process, and while some improvement may follow, especially if associated with inflation and other forms of treatment, permanent improvement is rare from this form of treatment alone.

Incision of the Tympanic Membrane—*Myringodectomy*—is sometimes employed in the treatment of certain forms of this affection (see p. 74). There are

two conditions in which incision of the membrane may be useful. The *first* is that of an extremely retracted membrane with great prominence of the posterior fold and short process. In such a condition, if the hearing be very defective, and the subjective sounds very distressing, a perpendicular section through the middle of the posterior fold is not unfrequently attended by benefit, especially as regards the sounds in the ear. The good effects of such an incision depend on the partial setting free of the manubrium and its assumption of a more normal position. Of course, no effect can be hoped for when the fenestral structures are rigid or the ossicular chain anchylosed. It has to be added that while the relief is sometimes permanent it is, unfortunately, more frequently only temporary. The *second* condition in which incision of the membrane may be beneficial is in the case of the atrophied or flaccid membrane. Three or four incisions are made in the atrophied part. They heal usually in twenty-four hours, and should be repeated every fourth day for two weeks. The beneficial effects are due to the contraction of the linear cicatrices and the consequent firming up of the flaccid tissue. In some cases these multiple incisions are followed by a very good and permanent effect; in others the good effect is only temporary, while in some there is no improvement at all. The treatment is, however, almost free from any risk of inflammatory complication.

A permanent artificial opening in the tympanic membrane is very difficult to maintain. Attempts have taken the form of excision of a portion of the membrane, of introducing an eyelet into the opening (Politzer), of removal of a part of the manubrium and the severing of the vessels which supply the membrane, of cauterizing the edges of the opening, or of applying concentrated sulphuric acid; and they have all equally failed. In the course of time, usually in not more than two or three months, cicatricial tissue forms, and the artificial perforation is closed. The best method, introduced by Voltolini, consists in burning a hole in the membrane with the galvanic cautery (see p. 80). The point of the burner is applied to the postero- or antero-inferior quadrant with very slight pressure so as to avoid burning the inner wall of the tympanum. This method, though perhaps the best yet tried, has not brought us to the desired goal. It is found that the opening made in this way generally heals in course of time. If it were possible to maintain a permanent opening, a certain number of cases of deafness would undoubtedly be improved. When the tympanic membrane is so thickened or changed that the sound waves cannot be properly transmitted by it, or where the Eustachian tube is completely occluded, while the *fenestral structures are freely movable and the labyrinth intact*, an opening in the membrane is likely to improve the hearing and probably relieve the subjective sounds. And it is found by experience in these cases that so long as the opening remains the improvement continues; but, as soon as it is closed by a cicatrix, the improvement disappears. The author has found in some cases of extremely distressing subjective sounds marked relief so long as a perforation made by the galvanic cautery remained open.

Division of the Tendon of the Tensor Tympani Muscle. This operation is best performed with Hartmann's curved tenotome. An incision is made parallel with, and immediately behind, the handle of the malleus. The tenotome is then introduced between the manubrium and the long process of the incus and the tendon is cut *from below upwards*. If it were possible to ascertain with certainty in any case that the deafness and subjective noises

depended solely or even mainly upon retraction of this muscle, division of its tendon would be a justifiable and even a reasonable proceeding. But we are not able to do so, and it is well known that in nearly all cases of retraction of this tendon, adhesions, thickenings, and contractions of various kinds exist at the same time in the cavity of the tympanum. As might be expected, therefore, good results from this operation are either temporary or altogether absent. It is also to be remembered that there is a possibility, as experience has shown, of damaging the hearing still further. If attempted at all, it should be done where the deafness is already of an extreme character, and where the tinnitus is such as to demand every effort to relieve it. Politzer says that "it is one of those operations which not only are of but trifling use, but which sometimes also have a deleterious influence upon the function of hearing."

Kessel's Operation for the Mobilization and Extraction of the Stapes in anchylosis of the latter need not be described here, as it is still in the experimental stage, its usefulness or safety being far from established.

Synechotomy of the Crura of the Stapes has been recently suggested and performed by Politzer. This operation is for dividing or separating adhesions between the crura of the stapes and the walls of its niche. He admits that further experimental operations are necessary before deciding upon its usefulness. The description of the operation will be found in the third edition of his own work.

Excision of the whole Tympanic Membrane and the Malleus or Malleus and Incus has been already described, and its value indicated at p. 101, to which the student is referred.

Section of the Anterior Ligament of the Malleus has also been proposed by Politzer when there is marked drawing in of the tympanic membrane.

Value and Limitations of Local Treatment. In concluding this review of the local treatment of the various pathological conditions found in non-exudative inflammation, it may be stated, as the experience of aural surgeons, that in most cases all the benefit to be derived from local treatment of the ear is secured by inflation of air. In a certain number of cases, however, a greater effect is achieved by alternating the air-inflation with the injection of fluids or the introduction of vapours. An important question to decide is, how long should treatment be continued. It may be said that if no improvement results either in the hearing or in the tinnitus after a month's treatment, carried out on the lines which have been laid down, the surgeon is justified in abandoning local treatment as likely to be useless; indeed rarely does any improvement *begin* after two or three weeks' treatment. If, on the other hand, appreciable improvement take place at an early stage, so long as this improvement gradually progresses the treatment should be continued. When no further improvement is observed, the surgeon must be careful *not to prolong the treatment* over too great a space of time, otherwise the advantage gained may be completely lost. The maximum of good is usually attained in less than six weeks. After this a pause should be made

of two or three months, and then inflation should be again practised either with the catheter or by Politzer's method, according as either of these answers best. If Politzer's method serve the purpose, the patient may go on with it at home every second day for six weeks. After this the surgeon must be guided as to the propriety of further local treatment by the state of the patient. In many cases it is found that in order to maintain the improvement or to prevent relapse, the local treatment requires to be repeated at least twice a year, for six weeks at a time.

It has to be confessed, however, that there are cases, especially of the sclerotic character, which, in spite of all treatment, advance until a condition of almost total deafness has been reached. In a few instances local treatment *seems to have rather an injurious influence*. Where the deafness is but slight, and where objective examination of the ear shows no apparent morbid change, local treatment, even by simple inflation, should not be attempted.

If by treatment the surgeon is able to check the morbid processes, although no actual improvement in the hearing has been gained, he not merely saves the hearing power which remains, but also diminishes the tendency of the good ear to become affected (see p. 334). We have to add that, while no improvement in the hearing or relief to the sounds in the ear may result from treatment, the patient in some cases finds relief from the nervous symptoms which are frequently complained of in connection with this affection.

(2) **Attention to the Nasal and Pharyngeal Mucous Membrane** —the *second* part of the treatment of non-exudative inflammation of the middle ear—must never be omitted by the surgeon. This region should be carefully examined in every case, and any morbid condition which may exist properly treated. The treatment of the naso-pharyngeal mucous membrane *is sometimes of even greater value than the purely aural treatment*, and has frequently to be continued after the latter has ceased. If the patient has a rooted tendency in winter time to catarrh of the nose and throat attended by aggravations in the deafness, the desirability of removing to a southern climate in winter time should be considered, if circumstances permit. The student is referred to the chapter on Diseases of the Nose and Throat, and specially to the Treatment of the Nose and Throat (Chapter VI.), for a full consideration of this subject.

(3) **Constitutional Treatment** is of use when a cachectic condition exists, such as the strumous, tubercular, anæmic, or syphilitic diathesis (see Formulæ for General Remedies). Appropriate treatment for these conditions, if they exist, must never be neglected. If subjective sounds be the chief or only symptom complained of, there are certain special remedies which are discussed at p. 373. The

condition of the digestive system should be inquired into, and any defect remedied; while the gouty or rheumatic conditions when present should be treated with suitable remedies, such as Carlsbad salts, alkaline medicines, etc., either at home or preferably at a spa.

Mr. Field has reported beneficial results from the use of pilocarpine hypodermically in this class of cases (see p. 365).

Hygiene is also of importance in the prevention and treatment of this disease. This subject has been already considered in the chapter on Methods of Treatment at p. 103, to which the reader is referred.

CHAPTER XVI.

DISEASES OF THE INTERNAL EAR.

ANATOMICAL AND PHYSIOLOGICAL DESCRIPTION.

THE OSSEOUS LABYRINTH.

The membranous labyrinth is contained in an unyielding casing, the *osseous labyrinth*. This consists of spaces, corresponding in shape with the membranous labyrinth, in the petrous part of the temporal bone. These spaces are filled with a watery fluid, in which are suspended the membranous structures. Supposing a metallic cast were made of the cavities, as depicted in Fig. 224, there would be found to be three distinct divisions. There is a central space, named the *vestibule*, which communicates with the tympanic cavity by the fenestra ovalis, closed in the fresh state with membrane and by the foot-piece of the stapes, and situated in the inner wall of the tympanum. From one side of this central cavity there spring three arched canals — the *semicircular canals*; while on the opposite side there opens into the vestibule a peculiar spiral tube, which, from its resemblance to the shell of a snail, is called the *cochlea*. The membrane closing the fenestra rotunda separates the interior of the cochlea from the interior of the tympanum. Thus, like the outer and the middle ear, the inner ear is divided into *three* parts, the vestibule, the semicircular canals, and the cochlea. The inner wall of the vestibule and the base of the cochlea are pierced by a number of apertures, through which the fibres of the auditory nerve pass from the internal auditory canal to the membranous structures (Fig. 225).

FIG. 224. Right osseous labyrinth (after Sommerring) × 2½. 1, 1, Vestibule; 2, fenestra ovalis; 3, superior semicircular canal; 4, horizontal or external canal; 5, posterior canal; 6, first turn of the cochlea; 7, second turn; 8, apex; 9, fenestra rotunda; *, ampullæ.

The Cochlea is the most anterior part of the labyrinth. It has a conical shape, its base being towards the end of the internal auditory canal, and its apex, the *cupola*, towards the osseous part of the Eustachian tube. From the base to near the apex extends a pyramidal pillar, the *modiolus*, which is pierced in the direction of its long axis by canals conveying the fibres of the auditory nerve destined for the cochlea, as well as small blood-vessels. The space between the outer wall of the cochlea and this central part is divided into two winding passages

or "staircases," *scalæ*, lying over one another, by a partition which winds in a spiral direction from the base to the apex, *the spiral plate of the cochlea*, and extends between the central pillar and the outer wall. This partition is in part bone and in part membrane. The bony part, springing from the central pillar, reaches half across the interval, while the membranous part completes the other or outer half.

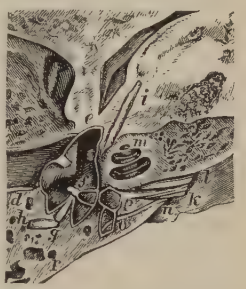

FIG. 225.—Horizontal section through the tympanum and labyrinth (after Rüdinger)—*a*, the tympanic membrane; *e*, anterior wall of cavity of tympanum; *f*, stapes with its foot-piece attached to the fenestra ovalis; *g*, stapedius muscle; *h*, a portion of facial nerve; *i*, situation of tensor tympani muscle; *k*, vestibular division, and *l*, cochlear division of auditory nerve in the internal auditory canal; *m*, section of the cochlea; *n*, nerve going to the ampullæ; *o*, section of utricle; *p*, section of saccule; *r*, section of a semicircular canal.

Scalæ of the Cochlea. This so-called membranous part of the partition is in reality a triangular space—*the membranous canal of the cochlea or scala media*—containing structures of great complexity, bounded above and below by membrane. In using the terms *above* and *below* the cochlea must be imagined standing with its base down instead of backwards as in the body. This partition begins between the fenestra ovalis and fenestra rotunda, and, winding round the central pillar for two turns and a half, terminates near the apex. Of the two winding passages formed in this way the upper is called the staircase of the vestibule, *scala vestibuli*, because it opens directly into the vestibule; and the lower, the staircase of the tympanum, *scala tympani*, because in the macerated bone it passes directly into the tympanum at the fenestra rotunda, although in the recent state it is separated from the tympanum by the membrane closing that opening. These two *scalæ* open the one into the other at the apex by a small aperture, the *helicotrema*. There is a canal of communication, the *aqueductus cochleæ*, between the scala tympani, near the fenestra rotunda, and the interior of the cranium, near the lower margin of the posterior surface of the petrous bone. Many small passages, continuous with the canals in the central pillar, pierce the osseous spiral plate, and convey vessels and nerves to the membranous partition.

The Perilymph. A membrane composed of connective tissue lines the osseous surfaces of the interior of the labyrinth. This periosteal membrane, lined by a layer of epithelium, secretes a thin fluid, the *perilymph*, which fills the two scalæ, and occupies the space between the walls of the osseous labyrinth and the membranous tubes and sacs contained in the vestibule and semicircular canals. This perilymph communicates with the arachnoid space through the aqueductus cochleæ.

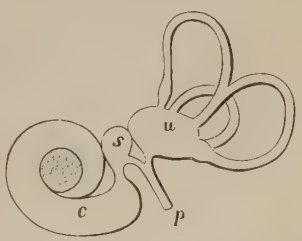

FIG. 226. — Membranous labyrinth (M'Kendrick)—*u*, utricle communicating with the semicircular canals; *s*, saccule communicating with the membranous canal (*c*); *p*, aqueductus vestibuli.

THE MEMBRANOUS LABYRINTH.

The *membranous labyrinth* (Fig. 226) is divided into two parts, having a communication with one another.

Utricle and Semicircular Canals. The one consists of the *utricle*, suspended in the perilymph of the vestibule, and three tubes suspended in the perilymph of the three osseous semicircular canals. The three membranous tubes in the semicircular canals are of much smaller calibre than the osseous canals—the latter

being fully four times wider than the former. The utricle and the three tubes form one cavity, which is filled with fluid, the *endolymph*. A delicate membranous tube, the *aqueductus vestibuli*, passes from the utricle through a firm osseous canal and terminates in a *cul-de-sac*, covered by dura mater, on the posterior surface of the petrous part of the temporal bone. Each of these three tubes has at one end a bulging, *ampulla*, occupying a similar ampullary widening of the osseous labyrinth. The utricle and each of the three ampullary enlargements of the membranous canals present at one part on the inner surface a thickening, *macula acoustica*, corresponding to the entrance and ramification of the branches of the auditory nerve to these parts. At these thickened parts the *otoconia*, or small crystals of the ear, are found. In the membranous semicircular canals no nerves have been found except at the ampullary widenings.

Saccule—Membranous Canal—Canalis Reuniens. The second division of the membranous labyrinth consists (1) of a round bag, the *sacculi*, suspended in the perilymph of the vestibule; (2) of a long but narrow winding passage, having a triangular shape, *the membranous canal*, *cochlear duct*, or *scala media*; and (3) of a very slender tube of communication between the two, the *canalis reuniens*. By means also of another short membranous tube the saccule communicates with the aqueductus vestibuli (see Fig. 226). The membranous labyrinth thus forms one continuous irregular cavity filled with endolymph and surrounded by perilymph. The saccule, like the utricle and each of the membranous semicircular canals, has an enlargement indicating the place of entrance and distribution of the auditory nerve.

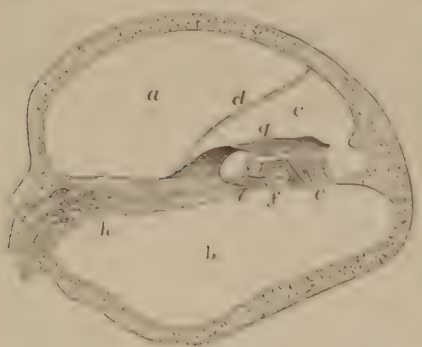

FIG. 227.—Cross-section of a turn of the cochlea (Landois)—*a*, scala vestibuli; *b*, scala tympani; *c*, membranous canal, or cochlear duct; *d*, Reissner's membrane; *e e*, Corti's cells, and *f*, Corti's rods, both resting on the basilar membrane; *g*, Corti's membrane or membrana tectoria; *h*, osseous spiral lamina.

The Membranous Canal of the Cochlea (Fig. 227, *c*) contains what is now regarded by physiologists as the most essential part of the terminal apparatus of the auditory nerve, namely, the *organ of Corti*. This canal is situated between the scala vestibuli and the scala tympani. The thin membranous partition, between it and the scala vestibuli, is termed *Reissner's membrane*, and passes obliquely from the upper surface of the osseous spiral lamina to the outer wall of the cochlea, while the partition between this membranous canal and the scala tympani is termed the membranous spiral lamina, or the *basilar membrane*, connecting the edge of the osseous spiral lamina with the outer wall of the cochlea.

The Organ of Corti lies on the upper surface of the basilar membrane, inside the membranous canal and immersed in the endolymph. This remarkable structure consists of a double series of rods or fibres, an outer and an inner, arranged on the upper surface of the basilar membrane along its whole length. These two rows are jointed together at their upper ends so as to form an arch. There are more of the rods in the inner row than in the outer, so that three of the inner rods are sometimes attached to two of the outer. In the human cochlea there are supposed to be 3000 of the outer rods and still more

of the inner rods. They gradually increase in length towards the *upper* part of the cochlea. External to the outer row of Corti's rods there are several rows of elongated cells (Corti's cells), resting by their lower ends on the upper surface of the basilar membrane, while their upper extremities are furnished with fine hairs projecting into the endolymph. Within the inner row of Corti's pillars another row of these cells is found, also furnished with hairs. It has been shown by Waldeyer and Gottstein that these cells are *in connection with the ends of the fibres of the cochlear nerve*, which, branching from the nerves passing through the central pillar of the cochlea, reach Corti's cells by delicate cross canals in the osseous spiral lamina.

The Auditory Nerve has its origin at the back part of the medulla oblongata in the floor of the fourth ventricle. While the arrangement of the roots is still a subject of investigation, it is so far made out that they are connected with the grey matter of the cerebellum, the floor of the fourth ventricle, the restiform body, and the lower border of the pons. The researches of Ferrier seem to show that the temporal lobe of the cerebrum of the opposite side contains a centre of the auditory nerve, and that the fibres of the nerve decussate in their course from that centre to the ear. No fibres of the auditory nerve can, however, be traced to the temporal lobe.

From the medulla to the inner end of the internal auditory canal the auditory nerve is in contact with the facial nerve, and in that canal they are connected by one or two filaments. A small artery destined for the labyrinth usually lies between them. In the internal auditory canal the nerve divides into two sets of fibres. One set, the cochlear, pierces the front of the cribriform lamina below the opening of the aqueduct of Fallopius, and ascends in small canals through the centre of the modiolus, branching off through the osseous spiral lamina to end in Corti's hair-cells in the membranous canal. The fibres forming the other set—the vestibular nerve—pierce the back part of the cribriform lamina, and pass to the ampullæ of the membranous semicircular canals and to the utricle, where the nerve fibres terminate in cells with small hairs, which project into the endolymph.

FUNCTIONS OF THE LABYRINTH.

Sonorous Vibrations are conducted to the fluid in the labyrinth in two ways: (1) By the special sound-conducting apparatus provided in man and in all air-breathing animals—this is sometimes called "air-conduction of sound"; and (2) by the bones of the head either from direct contact of the vibrating body, direct osseous conduction, or by the waves of sound reaching the surface of the head through the air, indirect osseous conduction.

The Vibrations of the Stapes place the fluid of the labyrinth in a state of oscillation. The minute wavelets, thus set in motion, stream through the spaces and passages of the labyrinth. Multitudes of little taps or blows impinge upon the terminal structures of the auditory nerve in the various parts of the membranous labyrinth; some kind of change is thus produced in the nerve, which is at once conveyed to the brain, and in a way unknown to us these purely physical movements of matter are transformed into that sensation which we designate sound.

An inward movement of the base of the stapes produces an outward movement of the membrane of the fenestra rotunda; the wave of fluid displacement passes along the scala vestibuli of the cochlea through the helicotrema to the scala

tympani, at the end of which it presses upon the membrane of the fenestra rotunda, which then bulges towards the tympanic cavity. On the other hand, in every movement of the stapes outwards this membrane sinks into the scala tympani. It is thus easy to see that thickening or rigidity of the membrane of the fenestra rotunda must have a disturbing influence upon the vibratile movements of the labyrinthine fluid. Through the aqueductus cochleæ the perilymphatic space is connected with the subarachnoid space, and the perilymph, if exposed to great pressure, may be forced into the subarachnoid space, or, on the other hand, excessive pressure on the cerebro-spinal fluid may force it into the labyrinth. In the former case injury to the delicate nerve structures by excessive pressure may be averted, while in the latter way morbid conditions of the subarachnoid space may be communicated to the labyrinth.

The special function belonging to each of the three divisions of the inner ear is still a matter of uncertainty.

The Function of the Vestibule was supposed to include perception of noises as distinguished from musical tones. This view has, however, been refuted by the experiments of Ranke and Hensen, and is no longer held by physiologists.

The Function of the Semicircular Canals has been the subject of very great inquiry by many and able experimenters, who are, however, not agreed. From the peculiar relation of the semicircular canals to each other, it has been supposed by some physiologists that they are connected with the faculty of distinguishing the direction of sound. The hypothesis, however, which has provoked the greatest discussion, is that which ascribes to this part of the labyrinth the centre of the power by which the movements of the muscles of the body are so co-ordinated as to enable us to maintain the upright position. This view originated in experiments of Flourens, who found, after severing the semicircular canals in the pigeon and rabbit, that peculiar rotatory movements were executed by the animals. Goltz, Mach, Crum-Brown, etc., confirmed by experiments the results obtained by Flourens, and the view seemed to be fairly established that the semicircular canals were the "static organs" of the body, and had nothing to do with hearing. Other eminent experimenters, however, such as Böttcher, Baginsky, and Moos, alleged that these peculiar movements were due to injury inflicted on the cerebellum by the manipulations necessary in performing the vivisection. It has been found more recently that simple injury to the canals without division is followed by motor disturbance, while the complete destruction or severance of the membranous semicircular canals does not produce this effect.

The view most generally accepted at present is that some special nervous connection exists between those fibres of the auditory nerve which go to the ampullæ and vestibule, and certain parts of the cerebellum; and that, when these become irritated or injured, a reflex effect is produced on the cerebellum, expressing itself in disturbances of the equilibrium of the body. We shall see afterwards the bearing of this upon the cause of *giddiness* as a symptom of certain forms of ear disease.

The Function of the Cochlea. Physiologists are generally agreed that the *cochlea* is the most important and most highly developed part of the labyrinth. According to the most generally accepted theory of hearing, the terminal apparatus of the cochlear nerve has for its function the recognition and analysis of musical tones. Hensen, supported by Helmholtz, believes that the fibres of the basilar membrane, which are in connection with the ends of the nerve through Corti's cells, may be regarded as a vast number of stretched strings of all lengths, and

that only those of them are set into vibration which correspond with the particular tone which at the moment enters the ear. In this way long fibres vibrate in unison with low tones, and short fibres with high tones.

DISEASES OF THE INTERNAL EAR.

It has been found that diseases *primarily* affecting this section of the organ are much rarer than was formerly believed. In records by the writer of 1088 cases, already referred to, only 48, or $4\frac{1}{2}$ per cent., of the whole were diseases affecting primarily the internal ear. But *secondary* disease of the labyrinth is more frequently met with. When a disease, such as non-exudative inflammation, has existed for a length of time in the middle ear, the structures of the labyrinth are apt to become involved. As we can rarely affirm, merely from the clinical facts of a case, what is the exact pathological condition of the internal ear, or even in what part of the internal ear the lesion is situated, we shall simply discuss the diseases in a general way under the following aspects: (1) The most frequent pathological conditions found; (2) the varieties, based chiefly upon causation; (3) the symptoms manifested by them; (4) their diagnosis; (5) their treatment.

PATHOLOGICAL ANATOMY.

Toynbee, Voltolini, Kramer, and other observers have done a great deal in laying before us the coarser pathological anatomy of the internal ear. The most frequent pathological changes, which many sections of the internal ear have shown to exist, are the following:

Changes in the Labyrinth. Hyperæmia, acute purulent inflammation, extravasation of blood or serum, thickenings of the membranes of the labyrinth, atrophy of the same, pigmentary collections, anæmia, fibro-muscular tumours, cholesteatomatous masses, caries or necrosis of the walls of the labyrinth, exostosis of the osseous walls, defect or excess of otoliths, defective formation of semicircular canals, vestibule, or cochlea, absence of fenestral openings.

Changes in the Root, Stem, or Terminal Branches of the Auditory Nerve. Atrophy due either to the pressure of tumours, such as sarcomatous, cancerous, or tuberculous masses, or to defective nourishment of the nerve, or to disease in the cerebellum or medulla at the root of the nerve; inflammatory softening extending from the labyrinth or meninges, calcareous change, fibrous degeneration of the sheath, fatty metamorphosis, pigmentary deposition, formation of corpora amylacea.

Pathological Conditions of the Central Nervous System may involve the auditory centre or stem of the nerve, such as an apoplectic clot, softening of the brain substance, cerebral or cerebellar abscess, tumours, tubercular deposition, inflammation of the brain or meninges.

VARIETIES OF AFFECTIONS OF THE INTERNAL EAR.

(1) *PRIMARY OR ACUTE AFFECTIONS OF THE LABYRINTH.*

These are usually due to sudden pressure exerted upon the terminal structures of the auditory nerve by simple congestion, inflammation, serous or plastic exudation or hæmorrhagic effusion into the cavities of the labyrinth.

Abnormal States of the Constitution or Blood are the most frequent sources of these attacks, and the author's experience would place syphilitic disease, either in the hereditary form or during the tertiary stage of the acquired form, among the most important. Effusion of blood into the cavities of the labyrinth from rupture of a vessel specifically diseased is probably the most common. Such effusions constitute irritative lesions which act upon the auditory nerve terminals. The degenerative changes in the blood-vessels, connected with Bright's disease, are no doubt in some instances the cause of the hæmorrhage.

Atheroma of the vessels is, in elderly people, a source of the disease. When we consider that the internal auditory artery is a branch of the basilar, it is easy to understand that atheroma in the cerebral arteries is likely to be associated with a like degeneration of the labyrinthine vessels.

In young children the condition may be associated with mumps, acute labyrinthitis of Voltolini, cerebro-spinal meningitis, or leucocythæmia.

Traumatic Causes. The hæmorrhage may, on the other hand, be due to a blow or a fall on the head. Excessive exertion, especially of the respiratory organs, occasionally excites effusion into the labyrinth. For example, the author has had under his care an enthusiastic football player, who, during a keenly-contested game of football, was seized with great giddiness and excessive noise in one of the ears, which also became deaf, the latter symptoms—the noise in the ear and the deafness—remaining ever after. In another case, excessive blowing with the mouth in the use of a blow-pipe for several hours seemed to be the exciting cause of the disease.

Exposure to cold, while overheated or during exhaustion, may likewise be the exciting cause.

The disease may come on while the patient is in bed, the sensation of the bed heaving, as if in a ship in a storm, being the first indication of the seizure.

Primary Labyrinthine Disease is frequently known by the name of Ménière's Disease. Ménière in 1861 described a series of symptoms, which he held to be due to a pathological condition in the semicircular canals.

These symptoms consist in a sudden attack of *giddiness or staggering*, causing the person to fall to the ground, or to turn or wheel to one side. *Nausea or vomiting*, and at times fainting, are sometimes present, but rarely unconsciousness. At the moment of the attack, or immediately after, *deafness*, usually very decided, is experienced on one or both sides along with *great noises in the ear*. In some cases there is pallor of the face, with cold sweatings. The suddenness of the attack and the character of the symptoms may give rise to the suspicion of a lesion in the brain. And, as in point of fact it is often due to sudden hæmorrhage into the labyrinth, it is designated by Knapp *apoplectiform deafness*. The attack may take place in a person previously free from any affection of the ear, or in one who has already had some affection of the middle ear, especially non-exudative inflammation.

In many cases the deafness and noises in the ear prove permanent, while the other symptoms pass off after a period varying from a few minutes to several days. A greater or less tendency to stagger often continues for a time, with some giddiness. Frequently, however, after an interval of variable duration, a renewed seizure takes place, followed by another interval; and these may continue for years. Usually after each attack the deafness becomes more profound. It has been observed in some cases that, when a state of complete and permanent deafness had been reached, the attacks ceased to occur.

Ménière based his Opinion as to the Pathological Seat of the Disease—(1) On the examination, after death, of the head and ears in a case which presented in a marked form the symptoms just described. In this case while he found no lesion in the brain or interior of the cranium, the semicircular canals were occupied by reddish lymph. (2) On the theory of the special function of the semicircular canals, which ascribes to this part of the ear the power of controlling the equilibrium of the body.

The term Ménière's Disease should only be applied to those cases in which the symptoms come on suddenly in a person previously in good health and with normal hearing, and in which, on examining the ear very soon afterwards, no evidence of recent disease is found in the external or middle ear. The strong presumption in such a case, if there be no disturbance of any of the other cerebral or spinal nerves, is that we have to do with a sudden pathological change in the interior of the labyrinth, probably an effusion of blood or an exudation of lymph, in such a position as to press upon and irritate the vestibular and ampullary nerves.

Disease in the Middle Ear, such as effusion into the cavity of the tympanum, producing great pressure upon the fluid of the labyrinth *through the fenestral membranes*, may excite the symptoms included in the term Ménière's disease. If, as is probably the case, there are nerves in the ampullæ or vestibule, the irritation of whose fibres transmitted to some centre in the cerebellum produces giddiness and other disturbance of the equilibrium, any kind of pressure acting upon the fluid of the labyrinth, if sudden and severe, may irritate them, culminating in a seizure of Ménière's disease.

(2) *DISEASE OF THE INTERNAL EAR SECONDARY TO MORBID INTRA-CRANIAL CONDITIONS.*

Disturbances in the Brain Circulation. The nutrient artery of the labyrinth, *the internal auditory* from the basilar, is really a

brain artery. Hence, disturbances in the vaso-motor control of the arterial system of the brain or meninges are likely also to involve the vessels of the labyrinth. So, a narrowing or closure of the internal auditory artery or of the basilar, from pressure or other cause, may result in an anæmic condition of the labyrinth. Aneurism of either of these vessels will also affect the circulation of the labyrinth. Atheromatous conditions of the arteries of the brain are also usually associated with atheroma of the vessels of the labyrinth, leading sometimes to hæmorrhage into the latter. Again, *the veins of the labyrinth* discharge their contents chiefly into the superior petrosal sinus of the dura mater. Hence, any obstruction of this venous channel or of any of the large venous channels passing out of the interior of the cranium may lead to a passive congestion of the vessels of the labyrinth.

The Auditory Centre, or the stem of the nerve, may be affected by pathological conditions in, or acting upon, the brain, such as embolism, inflammation of the brain or meninges, syphilitic, cancerous, or tubercular tumours in the brain, softening of the brain substance, or abscess. In these cases the nerve at its centre, or in its course, is either pressed upon or shares in the pathological process.

Epidemic Cerebro-spinal Meningitis seems to be not unfrequently attended or followed by complications in the labyrinth or auditory nerve, leading to total deafness; and it is one of the most common causes of acquired deaf-mutism. In the somewhat limited number of sections of the ear which have been made after death from this disease, changes have been found in some cases in the root of the nerve, and in others in the vestibule and semicircular canals. In some instances the labyrinth and tympanic cavity were found to contain purulent matter.

The Aqueducts of the Vestibule and Cochlea are also channels by which morbid processes in the interior of the cranium may be propagated to the interior of the labyrinth.

(3) *DISEASE OF THE INTERNAL EAR SECONDARY TO AFFECTIONS OF THE MIDDLE EAR.*

Inflammatory Conditions of the Middle Ear, and even of the external auditory canal, may be associated with hyperæmia, and even serous or hæmorrhagic effusion into the labyrinth. The hyperæmia in the latter region may be due in these cases to vaso-motor reflex influence, but probably it is more frequently owing to direct vascular connection. These hyperæmic conditions of the labyrinth, which may co-exist with congestive conditions of the external or middle ear, are usually temporary, and pass off with the disappearance of the

peripheral inflammation. On the other hand, thickening or destruction of the labyrinthine membranes may in this way result.

Interstitial Inflammation of the Fenestral Structures in the middle ear frequently extends to the membranous and nervous structures of the labyrinth, causing thickening, induration, atrophy, etc., in the labyrinth similar to the tympanic changes.

Purulent Inflammation sometimes occurs, owing to caries or necrosis of the osseous walls of the labyrinth or to the pressure of cholesteatomatous masses, originating in purulent disease of the middle ear. Such extension is facilitated by the numerous spaces in the bone surrounding the labyrinth, which are in communication with the mastoid cells. Several cases are known of the whole or a part of the osseous labyrinth being exfoliated through the external auditory canal or mastoid process (see p. 273).

Excessive Pressure upon the Labyrinthine Fluid is probably the most important cause of labyrinthine disease, *acting from the direction of the middle ear*. This is exerted through the fenestral membranes, chiefly through the fenestra ovalis, and may be produced both by acute and by chronic diseases of the middle and external ear. The pressure may be due (1) to the foot-piece of the stapes being forced in upon the fluid of the labyrinth; (2) to the presence of air, water, or inflammatory products acting through the fenestral structures, or through a carious opening; or (3) to thickening of the membrane of the fenestra rotunda or of the annular ligament of the stapes. When we consider that the labyrinthine fluid is contained in a cavity with unyielding walls, except at the fenestral openings, and having no means of exit except through the two very slender aqueducts, it is easy to see that, if exposed to pressure at one of the fenestral openings, especially if the membrane closing the other opening be rigid, the delicate terminal structures of the auditory nerve must suffer. There is little doubt that if this pressure is continued for a great length of time permanent changes of the structures exposed to it must ensue. Probably sudden pressure produces greater functional disturbance than gradually increasing pressure.

Giddiness from Excessive Air-Pressure. Many examples of giddiness due to excessive and especially to sudden air-pressure upon the walls of the middle ear have come under the author's notice. The act of blowing the nose, by forcing a current of air into the middle ear, sometimes excites giddiness. A medical friend subject to ear giddiness informed the author that he has to blow his nose with the greatest care, otherwise giddiness and loss of balance are excited. The effects are still more striking where violent blowing of the nose is indulged in during the existence of a nasal catarrh with obstructed nasal passages. The pressing of air into the tympanic cavity by forced expiration, while the nose and lips are closed (Valsalva's experiment), is a still more fruitful source of giddiness. Tem-

porary giddiness may also be excited by inflating the middle ear either by Politzer's method or with the catheter.

Giddiness due to Syringing the Ear. The entrance of water into the middle ear through an existing perforation of the tympanic membrane often induces giddiness, sometimes of a violent character. Even where the tympanic membrane is intact, syringing the ear, especially if the water be too hot or too cold, or the force too great, excites giddiness in some persons. The danger, however, is much greater when the membrane is perforated by present or past purulent disease of the middle ear. In such cases, even nausea and vomiting may be excited as well as giddiness. It is possible that, in those purulent cases where giddiness is excited by syringing the ear, an aperture of communication, carious or otherwise, may exist between the middle ear and the labyrinth, through which the fluid may pass into the labyrinthine cavities or even into the interior of the cranium.

Fatal Ear Giddiness while Bathing. If the syringing of the ear is apt, in persons with perforated tympanic membranes, to induce giddiness, it is highly probable that the rush of water into the ear in such persons, while the head is submerged during bathing, may also excite giddiness. It is therefore surmised, and the author thinks with great probability, that death from drowning during bathing is sometimes connected, in the case of expert swimmers, not with exhaustion or cramp, but with the sudden occurrence of giddiness due to the rush of water into the canal of the ear, and into the tympanic cavity through a perforation which may exist in the membrane.

Giddiness from Pressure of Inflammatory Products. The pressure upon the walls of the middle ear of fresh exudation, or secondary inflammatory products, is a more important cause of vertigo than increased air or water pressure. Of the exudative diseases of the middle ear which may be attended by giddiness, the purulent forms are the most common. The pressure on the walls of the middle ear may be caused in the more chronic stages of a purulent affection by secondary inflammatory products such as cholesteatomatous masses, granulation tissue, polypi, or a sequestrum. These may excite violent giddiness. The simple exudative catarrhs of the middle ear, without perforation of the tympanic membrane, do not so frequently excite giddiness as the more acute purulent forms. Occasionally, however, we find striking exceptions.

Atrophy of the Terminal Nerve Structures may take place from the absence of the specific nerve stimulation, when a high degree of defective hearing, due to an affection of some part of the external and middle ear, has existed for a long time. Still it is frequently found that such a form of deafness may continue for a very long period without injury to the nerve, as shown by ultimate complete restoration of hearing.

(4) *DISEASE OF THE INTERNAL EAR PRODUCED BY CERTAIN GENERAL AFFECTIONS OR CHANGES WHICH INVOLVE THE CIRCULATION.*

Syphilis of the Internal Ear. Syphilis is probably the most important constitutional disease which may give rise to disease in the labyrinth. As we have seen, it may cause sudden exudation into the cavities of the labyrinth with Ménière's series of symptoms,

or a more gradual change in the labyrinthine structures. In non-exudative inflammation of the middle ear the poison sometimes exercises a most unfavourable influence upon the course of the disease by its effects on the labyrinth (see p. 338).

Syphilis of the labyrinth may manifest itself during the secondary period, but more frequently it affects the organ in the tertiary period, perhaps many years after the primary disease. In some cases no other symptoms of syphilitic disease are present.

FIG. 228.—Patient (aged 21 years) almost totally deaf from specific disease (hereditary) of the labyrinth, showing cicatrices radiating from the lips and angles of the mouth. She had also notched upper middle incisors, remains of keratitis, perforation of the soft palate, and disease of the bony framework of the nose.

Hereditary Syphilis of the Labyrinth. An affection of the labyrinth due to hereditary syphilis, usually following iritis or keratitis or both, is not unfrequently met with in young persons, leading to serious or even total deafness. These patients often present notched upper middle incisors (Hutchinson), and also cicatrices radiating from the lips and angles of the mouth (see Fig. 228), the remnants of ulceration in early life. Syphilitic disease of the bony framework of the nose often also co-exists in such cases. Several members of a family may be affected in this way, leading in some cases to loss of both vision and hearing.

Syphilis of the Labyrinth is usually characterized by extreme deafness, by great subjective noises in the ear, and sometimes by giddiness (Ménière's series of symptoms), with diminution or total abolition of the perception of sound by osseous conduction. These symptoms may come on very suddenly, and the disease usually affects both ears, although it is sometimes limited to one ear for months, after which the other may also become affected. It may occur in a person whose ears have been previously quite normal; but we frequently find that catarrhal disease of the middle ear, often originating before the syphilitic disease affected the system, though not of an extreme form, has existed previously. Suddenly, often in a night's time, the syphilitic poison attacks the labyrinth, and the moderate deafness, previously due to the catarrhal affection, becomes almost total and attended by distressing noises in the ear. Sometimes, again, we find that while a fresh catarrh evidently exists in the middle ear, the extreme character of the deafness and the indications derived from the state of the osseous conduction raise the suspicion that the catarrhal affection is complicated with mischief in the labyrinth.

The Zymotic Diseases, especially scarlet fever, enteric fever, and

typhus fever, are not unfrequently attended by disturbance of the auditory function without apparent disease of the external or middle ear. Labyrinthine deafness is found also to follow epidemic influenza in some cases. It is probable that these disturbances are due to hyperæmic conditions of the labyrinth, which in many cases pass off during convalescence from the general disease, but which sometimes lead to permanent mischief, shown by the persistence of the deafness or subjective sounds in the ear. Malarial fever seems to be followed in some cases by labyrinthine deafness, although the quinine which is given in these cases has probably a share in the production of the deafness. The labyrinthine deafness which sometimes follows rheumatic fever may in like manner be due to the salicin administered.

Degenerative Diseases of the kidneys and liver by their effect on the blood may give rise to changes in the labyrinth, especially in persons predisposed to ear disease.

Anæmia, either due to disease or to rapid loss of blood, may, through the anæmic state of the labyrinth, cause deafness and noises in the ear. The ringing in the ear, which often accompanies post-partum hæmorrhage, is an example of the effect of rapid loss of blood.

Mumps is in some cases associated with sudden and extreme deafness of a permanent character owing to changes, as yet unknown, occurring in the interior of the labyrinth.

Some Medicinal Substances seem to exercise a disturbing influence upon the labyrinthine circulation, manifesting itself by deafness, or by singing or other sounds in the ear. The chief of these substances are quinine, salicin, salicylate of sodium, opium, salts of morphia, and alcohol. Large doses of these are usually necessary to produce the effect on the ear, but with persons who suffer already from defective hearing even ordinary doses may aggravate the aural disturbance, and this aggravation *may remain permanent.*

(5) *DISEASE OF THE INTERNAL EAR EXCITED BY INJURIES OF THE EAR OR HEAD.*

A Blow or Fall upon the Head may, with or without fracture of the petrous bone, rupture the tissue in the interior of the labyrinth, cause effusion of blood, and produce great and permanent damage to the delicate terminal structures of the auditory nerve; or there may be tearing of the nerve in its stem or at its origin from the brain. The injury may, without fracturing the bone or tearing the soft parts, cause violent concussion of the delicate structures of the labyrinth or of the nerve, setting up great irritation of the terminal nerve structures or paralysis of their receptive power. Chronic inflammatory thickening of the membranous labyrinth

may be the issue of such a concussion. In these severe injuries, due to fracture or simple concussion, the effects are generally not confined to the labyrinth, but involve also the middle ear, in which there may be dislocation of the ossicula or rupture of the soft parts with effusion of blood into the cavity of the middle ear, and subsequent inflammatory reaction. In blows upon the ear, it is found that, if the force exerted by the compression of air in the external meatus is partially spent in rupturing or injuring any of the tympanic structures, the labyrinth either escapes altogether or sustains less injury than when the middle ear has not received damage. The effects of injuries to the labyrinth are usually also much more severe if any disease has previously existed.

Loud Sounds as a Cause of Ear Disease. It is familiarly known that boilermakers and others who work amid noisy surroundings are liable to dulness of hearing, and in this way very many persons have their hearing irremediably damaged. The author examined a hundred men employed in boilermaking, and found that very few had escaped injury. He found also decisive evidence to show that the nervous structures in the internal ear are essentially the seat of the mischief in this form of deafness. In the early stages of exposure there is a tendency for the disturbance of hearing to diminish or pass away if the person abandons the noisy employment.

The sudden report of a piece of artillery, or even the shriek of a railway whistle, may produce serious deafness from injury to the terminal structures of the nerve.

(6) *DISEASE OF THE INTERNAL EAR FROM REFLECTED VASO-MOTOR IMPRESSIONS.*

These impressions may bring about congestive conditions of the labyrinth, manifesting themselves in partial deafness and sounding in the ear, generally temporary in character. The vaso-motor connections of the labyrinth are wide and numerous. The effects of disturbance of the digestive process upon the ear may be explained from such a connection. The aggravation, which is often noticed in an aural affection during menstruation, pregnancy, and lactation, may be accounted for in like manner. So also the deafness and noises in the ear, usually of a very fluctuating character, which are associated with some forms of hysteria, are probably due to reflex disturbance of the circulation in the labyrinth.

Malformations of the Labyrinth. Serious or total loss of hearing may be due to malformations of the labyrinth, such as absence of the fenestral openings, defective formation of the vestibule, semicircular canals or cochlea, defect or excess of otoliths, absence of the auditory nerve. Congenital deaf-mutism is doubtless sometimes due to such malformations.

SYMPTOMS OF DISEASE OF THE INTERNAL EAR.

Disease of the labyrinth or auditory nerve manifests itself by one or more of the following symptoms: (1) Deafness, which is usually severe, associated with defective bone-conduction, defective appreciation of high notes, and partial tone-deafness (false hearing); (2) subjective sounds in the ear; (3) giddiness or staggering gait; (4) nausea or vomiting.

Defect and other Anomalies of Hearing. As a rule the deafness associated with disease of the labyrinth or nerve is much more extreme than in disease of the conducting apparatus, and is not confined to the ordinary mode of hearing by aerial conduction, but involves also perception by osseous conduction. From the mere intensity of the deafness, however, it is not possible to distinguish a lesion of the labyrinth or nerve. Very great deafness may exist in consequence of complete rigidity of the stapes and fenestral structures, but in this case it has usually advanced slowly and gradually. On the other hand, in disease of the labyrinth or auditory nerve the great deafness frequently comes on suddenly or progresses very rapidly. In Ménière's disease it is sometimes found to precede for a few hours the other symptoms, but in general it comes on almost simultaneously with the giddiness. As a rule, a loudly ticking watch is not heard close to the ear, neither are words whispered into the ear perceived. Bone-conduction is also defective, as tested both by Weber's and Rinne's tests. Objective examination usually shows nothing abnormal in either the external or the middle ear. Fortunately, in many cases, only one ear is affected. When the disease affects both ears in young children, deaf-mutism is generally the result. The deafness, like the noises in the ear, is in the majority of cases permanent.

Defective bone-conduction, as a symptom of an affection of the auditory nerve, is described at page 364; while partial tone-deafness, false tone-perception, and painful hearing are described at pages 37 and 38.

The Subjective Sounds in the Ear are always well marked, and in many cases they are most distressing features of the disease. In Ménière's disease they generally come on simultaneously with the vertigo, but sometimes they are not experienced for a few hours after, or, in rare cases, for a day or two. The characters of these sounds are variously described by patients. The following, taken from the author's note-book, are some examples: Sound of a shell, waves, railway whistle, bell, rushing, buzzing, loose shutters in the wind, singing, humming, ticking, roaring, rushing water and waving of trees, whistling, factory noise, twittering and whistling of

birds and crickets, blowing off steam, howling, hissing, flaring of gas, piano-playing, electric bell. The behaviour of these sounds is sometimes peculiar. For example, in the case of the electric bell, a sound precisely like an electric bell was heard, followed by half a minute or so of silence, then there again came the sound of the electric bell, followed by silence—this alternation going on continuously. In nearly all the author's cases the sounds in the ear connected with Ménière's disease, while varying in intensity at different times, remain permanent, and he has always found them present years afterwards, when he has had the opportunity of examining the patient.

Giddiness and Staggering—Auditory Vertigo (see Giddiness and Staggering as Symptoms of Ear Disease, p. 45). In acute labyrinthine disease the giddiness is very sudden and intense, and is usually the first symptom of the seizure. The objects around may seem to rotate, or the ground in front may seem to rise or fall, or there may be a sense of movement only in the patient's body, either that of rotation round a vertical axis or of moving backwards or forwards on a horizontal axis. There may simply be a staggering or want of control in the legs, especially in the dusk or dark, when the movements may resemble those of a drunken man. The patient is generally apt to turn or fall in the direction of the affected ear. If the attack commences while walking in the street, he staggers and tries to hold on by the wall or lamp-post. If he be in bed he feels as if in a ship in a storm. After a short time, from a few minutes to several days, the giddiness passes off or markedly diminishes, but it may return again, even repeatedly, although generally more slightly. A certain degree of staggering or giddiness is specially apt to return when the patient at first resumes the upright posture. It is apt also to be excited by sudden movement of the head, and it is often much worse in the dark. A gentleman recently informed the author that in the dark his legs collapse as if paralyzed, while in the light he has no difficulty in walking. Another patient says that in the dark "his legs go all ways," and he takes the whole breadth of the road, so that he avoids going out at night. He walks quite well during the day. The giddiness seems sometimes to be excited by superficial irritations, or by particular postures. A patient said that, when, in combing his hair, the comb touched a particular spot on the side of his head, he dropped on the floor and "felt like a spinning-top."

Giddiness from Disease of the Middle or External Ear. It is now generally recognized that *giddiness may exist with almost any form of disease of the ear.* We have already drawn attention to the fact that the labyrinthine fluid may be exposed to pressure from the direction of the middle ear through the fenes-

tral openings (see page 355). Accumulation of secretion, polypi, thickened mucous membrane, especially that lining the fenestral structures, undue pressure inwards of the ossicular chain—these may produce sudden or gradual pressure upon the fluid in the labyrinth, calling forth sudden and severe giddiness, or milder forms of it. But the irritation of the nerves in both the external and middle ear without direct pressure upon the labyrinthine fluid, may, in certain cases, give rise to giddiness. The most cautious manipulation of the ear may excite giddiness so severe that the patient falls to the floor. This may be due to a reflex connection with the semicircular canals; but more probably, the writer believes, it is owing to a reflex irritation of the cerebellum. There is no doubt that from the ear a reflected influence may be exerted upon the cerebellum, giving rise to cerebellar phenomena.

Middle Ear Giddiness contrasted with Labyrinthine. The whole of the symptoms of a true Ménière's attack may be produced by middle ear pressure, but in some the sickness and vomiting are absent. The vertigo may be extreme, or it may amount to no more than a staggering backwards when the head is suddenly turned round, especially to the affected side, with a tendency to fall forwards when the head is moved again to the front. Some patients complain of a staggering tendency in the dark, while others say they tend to fall if they turn quickly or stoop. An important distinction between this form of vertigo and the labyrinthine variety is that here the whole of the symptoms frequently disappear, the accessibility and nature of the region affected enabling us to remove, by operative or other treatment, the pathological cause. We found also in the class of cases due to primary labyrinthine mischief that, while the vertigo, sickness, and vomiting usually pass off, the noises and deafness generally remain permanent. In the present class of cases, on the contrary, not only are the vertigo, sickness, and vomiting amenable to treatment, but the noises in the ear are frequently got rid of, while the hearing is in many cases much improved, if not entirely restored. Middle ear giddiness also is frequently preceded by other symptoms of ear disease (unless in cases due to sudden air or water pressure), such as pain in the ear, defective hearing, subjective sounds, discharge from the ear, etc., in this way contrasting with the labyrinthine class of cases, in which we found that the giddiness is usually sudden and the first symptom complained of, although quickly followed by the other symptoms. In middle ear giddiness also the subjective sounds are rarely so distressing, nor is the defective hearing so extreme as in the former class of cases; while bone conduction of sound, as indicated by the various tests, is, in the great majority of cases, in excess of air conduction. This is, as we have already indicated, contrary to what is usually found in labyrinthine giddiness.

Circumstances which modify Symptoms when there is Labyrinthine Pressure or Irritation. While irritation of the terminals of the vestibular and ampullary nerves may be the basis, or, at least, the predisposing cause of vertigo, other systemic or distant local conditions may prove important modifying or exciting causes. No doubt, for example, digestive or hepatic disturbance, lithæmia or oxaluria may excite giddiness although the condition in the ear is the primary and central cause, and thus ear giddiness is often confounded with indigestion or biliousness. In some cases we find that the vertigo or the tinnitus is connected in its origin with some nervous shock such as bereavement or grief, or some mental strain, such as in the case of a student preparing for

an important examination. The disease strikes in the case of vertigo at the vestibular nerve, while in the case of subjective sounds the cochlear branch receives the blow. But in most of these a pre-existing, pre-disposing, ear disease has increased the vulnerability of the nerve.

Sickness and Vomiting are usually connected with acute labyrinthine disease, and begin soon after the disturbance of equilibrium, being probably due to reflex action through the vagus nerve. These symptoms naturally suggest the possibility of brain mischief. On the other hand, owing to these symptoms, both patients and practitioners *frequently regard such attacks as purely bilious in their nature.* The sickness and vomiting soon pass off, and rarely extend beyond a day or two.

Pallor of the face and cold sweats, with, in some cases, fainting, may be observed in Ménière's disease. Unconsciousness is rare and, if present, it is very short in duration. Headache is in some cases complained of. Depression, slowness of thought, and weakness of memory may follow for a time. Guye describes a peculiar trembling of the hand which he has seen in Ménière's disease.

From pressure in the sub-arachnoid cavity, transmitted through the aqueducts of the vestibule and cochlea, there may be caused irritation of the auditory nerve, or of the abducens and optic nerves at the base of the brain, producing nystagmus and disturbance of vision.

Giddiness with nystagmus may also sometimes be excited by the pressure of a probe upon the stapes, or by the pressure of syringing.

DIAGNOSIS OF DISEASE OF THE INTERNAL EAR.

In this inquiry, tests applied to determine the acuteness of the perception of sound conducted by the bones of the head are of the very greatest importance. The student is referred to Chapter II., page 39, for further details on this subject.

We must here distinguish two groups of cases—first, those in which examination by the external auditory canal and Eustachian tube shows little or no departure from health; second, those in which such an examination gives distinct evidence of disease in the external or middle ear.

Cases in which careful examination of the External and Middle Ear yields Negative Results. If a loudly ticking watch placed in contact with the bones of the head is not heard at all, we may suspect an affection of the nerve; this suspicion is still greater, if Politzer's acoumeter, when applied to the bones of the head, is not perceived by the patient. If the vibrating tuning-fork applied to the mastoid is not heard at all, or for a very short time, and if, after it has ceased to be heard on the mastoid, it is heard

when held close to the ear (aerial conduction), there is very great probability that there is disease of the labyrinth. The probability of a labyrinthine disease, or of a disease of the auditory nerve, is confirmed, if the patient is afflicted not only with a high degree of deafness, but also with great subjective sounds in the ear, and especially if the deafness and subjective noises have come on suddenly, with loss or marked diminution of the perception of sound by osseous conduction, as tested by Weber's and Rinne's tests.

On the other hand, if, after a long period of gradually increasing deafness, examination of the external and middle ear yields negative results, and if the tuning-fork by osseous conduction is distinctly heard, or, the affection being confined to one side, is heard better on the affected side, the probability is that the disease is in the conducting part of the ear, and that there is anchylosis of the stapes or thickening of the fenestral membranes. This is confirmed, if, after the tuning-fork has ceased to be heard near to the ear by aerial conduction, it is heard for some time when transferred to the mastoid process or vertex. It must not be forgotten that important changes may exist in the fenestral membranes, or in the recesses leading to them, *which cannot be recognized either by ocular inspection or by any other objective mode of examination.*

Cases which show a Decided Affection of the Middle Ear with diminished perception by osseous conduction. The affection is in the great majority of cases confined to the conducting apparatus, if the sound by osseous conduction be heard distinctly louder on the affected or worse side; or, both sides being equally affected, if the tuning-fork be heard as long as on our own persons—our own auditory nerves being healthy. On the other hand, secondary disease of the nerve is probably present if we have an affection of the middle ear which has existed during a very long period, perhaps from childhood, with very great deafness, while the sound by osseous conduction is heard better on the normal or better side; and especially if we have had the opportunity of tracing the course of the disease, and have noticed gradually increasing difficulty of hearing with gradually diminishing perception of the tuning-fork on the head. Or again, if a person who has suffered from catarrhal disease of the middle ear, with only moderate deafness, become suddenly very much worse, with great noises in the ear and diminished osseous conduction, there is great probability of a labyrinthine complication. In short, the failure to hear the vibrations of the tuning-fork by osseous conduction in chronic affections of the tympanum, especially if the deafness is increasing and attended by great noises in the ear, is presumptive of the existence of secondary disease of the nerve.

The presence of such anomalies of hearing as defective capacity for hearing high pitched notes or partial tone-deafness, and the *absence* of the phenomenon of hearing better in a noise, also point to a nerve lesion.

TREATMENT OF DISEASES OF THE INTERNAL EAR.

Treatment of Acute Lesions in the Labyrinth, or true Ménière's Disease. If the patient be seen in the early stage, when there is great vertigo, perfect rest in bed must be enjoined, along with restricted diet. Intestinal derivatives should be employed, such as a mercurial followed by Carlsbad salts, Hunyadi water, or other saline. Quietness is desirable, as loud sounds are not only intensely unpleasant, but they tend to aggravate the symptoms by irritating the nerve terminals. The bromine compounds are useful, especially dilute hydrobromic acid, in doses of 30 minims, twice or thrice daily, or bromide of potassium or sodium, in 30 gr. doses, at similar intervals of time. Alcoholic stimulants are to be avoided.

External applications may be employed at this stage, such as cold to the head, alcoholic or other stimulating embrocations behind the ear, or sinapisms to the neck or calves of the legs.

After a time, when the violence of the symptoms, especially the vertigo, has abated, other remedies may be resorted to. Iodide of potassium, mercurials, and the hypodermic use of pilocarpine have been found useful in appropriate cases and stages of the disease. They are especially indicated in syphilitic cases. The effects sought by these medicines are the stimulation of the absorbents so as to bring about the absorption of effused material in the labyrinth.

Iodide of Potassium and Mercurials. For this purpose, iodide of potassium may be given in large doses even to the extent of a drachm daily for three or four weeks. The amount should be gradually increased until these large doses are tolerated. The author has been informed of one and a half drachms being given with benefit thrice daily. A prolonged course of bichloride or of iodide of mercury may be recommended. Inunction of half a drachm of mercurial ointment every day into the armpits and inside of the thighs, varying the place in order to avoid irritating the skin too much, may succeed better in some cases. Ointment of iodoform or mercury rubbed behind the ear over the mastoid process may also be applied in the syphilitic as well as in other cases. The waters of Aix-la-Chapelle might in such cases be preferred to medicinal treatment at home.

Nitrate of Pilocarpine is conveniently used in the form of the tabloids of Burroughs, Wellcome and Co., beginning with one

eighth of a grain and increasing gradually to one fourth of a grain, if such be necessary to produce free salivation and diaphoresis; but sickness and vomiting must be avoided. A course of from fifteen to twenty hypodermic injections, one to be used daily, omitting every seventh day, will give this remedy a fair trial. For a few hours after the injection rest in bed is essential. It is not a remedy which should be used in anæmic or very feeble patients.

While these antisyphilitic remedies should usually be tried, we have unfortunately to admit that they do not, as a rule, seem to act so well in syphilitic disease of the labyrinth as in the same disease in most other regions of the body. Indeed, they frequently appear to exercise little or no influence upon the disease. In the acute exudative affections of the labyrinth, pilocarpine has occasionally a useful effect and we are justified in giving it a trial.

Quinine was recommended in Ménière's disease by Charcot to the extent of 15 grs. daily. There is, the author thinks, some danger of aggravating the symptoms by such large doses in the *early* stage of these labyrinthine cases.

Local Aural Treatment does not afford much prospect of benefit in these acute cases. In the more chronic stages the injection into the tympanic cavity through the catheter and Eustachian tube every second day for two or three weeks, of 8 to 10 drops of a solution of iodide of potassium (5 grs. to the oz.), or a similar quantity of a 2 per cent. solution of pilocarpine, might be employed with the hope of exercising a stimulating effect on the labyrinthine absorbents. Politzer recommends the insertion into the canal of the ear of a plug of cotton soaked in a mixture composed of equal parts of sulphuric ether and glycerine.

Acute Congestive Processes in the Labyrinth, when suspected, may be rationally treated by local blood-letting over the mastoid region. We know that the stylo-mastoid artery, which supplies the soft parts over the mastoid process, inosculates freely with the internal auditory artery in the tympanic cavity, and in this way a distinct vascular connection is brought about between the labyrinth and the external parts. When hyperæmia of the labyrinth is associated with cerebral congestion, cold to the head, purgatives, and the usual treatment of cerebral congestion must be employed.

While, by these modes of treatment, it may be impossible in most cases to remove the deafness or the tinnitus, the giddiness is usually favourably influenced, and there results also a greater sense of clearness in the head and relief of the mental depression so generally associated with these cases.

Chronic and Secondary Forms of Labyrinthine Disease. In regard to the treatment of these, many of which are related to, or

extensions from, middle ear disease, we should first examine carefully the external and middle ear to ascertain if any condition exists, the treatment of which might benefit the labyrinth. We may thus find that symptoms of labyrinthine disturbance, such as vertigo (with or without nausea and vomiting) and subjective sounds in the ear may be sometimes removed by such treatment as the removal of a cerumin-ous collection, incision of the tympanic membrane, inflation by the various methods, the application of vapours such as sulphuric ether or ammonia (Politzer) into the middle ear, the use of the pneumatic tractor, the opening of the antrum, the removal of a polypus, or the clearing out of cholesteatomatous or other inflammatory products. Even the treatment of nasal obstruction may have a good effect on labyrinthine disease secondary to middle ear disease.

Vesication over the mastoid process, by means of cantharides, is more likely to be serviceable in labyrinthine disease than in disease of the middle ear. When the symptoms prove persistent, vesication behind the ear repeated three or four times may be tried, and may sometimes prove advantageous.

For Paralysis of the Auditory Nerve vesicants over the mastoid region, iodide of potassium internally, and strychnine used hypo-dermically or by the stomach are recommended; and, no doubt, each of them is occasionally useful.

Quinine in small doses with hydrobromic acid is probably of more use in chronic and slighter forms of Ménière's disease than in the acute variety.

Medicinal disturbance of the labyrinth must, if possible, be avoided. Where chronic forms of deafness already exist, such medi-cines as quinine, and salicin with its compounds, should either be entirely abstained from or used with great caution. There is no doubt that permanent increase of deafness is not infrequently due to the use of these medicines. Subjective sounds caused by quinine are sometimes mitigated and even removed by hydrobromic acid.

Boilermaker's Deafness requires precautionary measures. With boilermakers, riveters, etc., a plug of cotton or an aural protector (see page 104) will help to protect the ear. In some cases abandon-ment of the noisy employment is essential in the interests of the ear, and is sometimes voluntarily adopted by apprentices.

The author in a paper on the "Injurious Effects of Railway Whistles upon the Sense of Hearing," suggested the following precautions: (1) The high-pitched railway whistle should be discarded as soon as possible in favour of a lower-pitched whistle; (2) some mechanical arrangement should be employed by which the current of steam passing from the boiler to the whistle may be easily regulated so that the tone may be at any time modified in its loudness and pitch;

(3) in stations, especially covered stations, and also when alongside passenger trains, at rest or in motion, special attention should be given by the drivers to avoid sudden, loud, high-pitched notes.

The Constant Galvanic Current (see page 78) is frequently employed in affections of the labyrinth, and especially of the auditory nerve. The most diverse opinions are held regarding its value. It should not be employed in the acute forms of disease, but rather when we suspect a torpid or paralytic condition of the auditory nerve, as shown by simple defect of hearing without subjective noises, and not due to disease of the external or middle ear. In order that this treatment may have a fair chance there should be at least ten or twelve sittings at intervals of three days, and each application should last for eight or ten minutes. When subjective sounds exist as a prominent symptom the continuous current very rarely relieves and in a few cases aggravates this symptom. When it is considered that we are still unable to differentiate precisely the pathological conditions present in the labyrinth or auditory nerve, it is easy to see that great diversity must be shown in the effects of such a remedy as galvanism.

The State of the General Health and the habits must be investigated, because in these the proximate cause may be found. The digestive and hepatic systems may be at fault, and then such remedies as Carlsbad salts with mercurials, along with judiciously regulated diet and habits, would be the true indications. Nerve exhaustion in the overtaxed student or the harassed business man may necessitate a prolonged period of rest or a lengthened holiday. Anæmia may have to be dealt with by means of iron, nourishing food, fresh open air, etc., or the syphilitic cachexia may demand special treatment. If such symptoms as vertigo and subjective sounds are severe, total rest in bed with the use of bromine preparations may be necessary. If, on the other hand, the symptoms are slighter, a moderate amount of open-air exercise may be very desirable. In the case of vertigo, the cheerful assurance of the physician that the vertigo does not imply any brain affection or impending brain affection, is very helpful to the patient. Noise and excitement must be avoided. The patient should also be warned, if vertigo be a feature of the disease, against climbing ladders, crossing planks, or placing himself in other for him similarly dangerous situations. Likewise sea or river bathing must be avoided, while, even in the house, a bath must only be taken in the presence of a second person.

Alcoholic stimulants are as a rule to be avoided, and tobacco should be only very moderately used.

Patients must avoid great bodily exertion or emotional excitement. Quick movements of the head, or stooping or rising up suddenly, are also likely to be injurious.

For the treatment of one of the most frequent symptoms of labyrinthine disease—subjective sounds in the ear—the student is referred to page 373.

CHAPTER XVII.

TINNITUS AURIUM.

By this term we mean sounds, which are perceived in the ear, but which have no objective cause outside the body. It is a common symptom in ear disease, and is sometimes a much greater distress to the patient than the defective hearing, with which it is generally associated. The worst forms of tinnitus aurium are met with in affections of the labyrinth and auditory nerve, and are, in most cases, due to irritation of the nerve. This is not infrequently the only symptom complained of by the patient, and the only one for which he comes for relief. They are described most frequently as being exactly in the ear, at other times as being in the side or back of the head, or "all over the head."

Two Classes of Sounds. These sounds are usually divided into two classes—First, those which are due to some irritation of the auditory nerve, either at its terminal expansion in the labyrinth, or in its course, or at its root in the brain, but *where no vibrating body really exists*; and second, those due to the actual presence of sonorous vibrations originating either in the interior of the ear or in the structures in its vicinity. The sounds comprised in this class are sometimes called *entotic* subjective sounds, and properly speaking are objective sounds, but they are usually included under the term subjective.

The Character of these Sounds as described by patients is extremely varied. It is evident in many cases that patients have a difficulty in describing them or in comparing them with any actual sound outside the body. In the efforts to describe them they often employ terms or comparisons suggested by their particular surroundings or occupations. They are frequently described as buzzing, hissing, ringing, singing of a kettle, humming, or crackling. They are compared by many to the sound of a shell held to the ear, to the ringing of bells, to the ticking of a watch, to the bursting of bubbles, to the splashing of water, to the twittering of birds, to the rustling of wind among the leaves of trees. Those of an intense character are compared to steam blowing out of a pipe, the rushing sound of a

waterfall, or the sound of water overflowing from a pot into the fire, or the constant shrieking of a locomotive. Some again are said to be of a beating or pulsating character, and are compared to a constant hammering or the working of a pump. In some cases several different sounds may exist at the same time in the one ear, such as a pulsating and a buzzing one. During treatment it is sometimes found that one sound may pass away or very much diminish, while the other may remain unchanged.

While the character of the sound is in many cases such as to produce very little annoyance, in others it seems to be so intense and constant as to render life a burden, forbidding work or social enjoyment, and indeed cases are on record, and known to the author, of patients seeking relief in self-destruction. Occasionally, though rarely, these sounds are said to be of a *pleasant* nature, such as the singing of birds or a beautiful melody. Complete tunes are sometimes alleged by patients to be heard in the ear without any objective cause. The writer had a patient, a lady, who frequently heard in the interior of the head complete and correct tunes of sacred music, particularly the tune "Old Hundred," to which the metrical version of the 100th Psalm is commonly sung.

The Sounds Vary in Intensity. Usually during stillness and solitude the noises appear to be much worse and more disturbing. Patients may declare that during the noise and bustle of daily work they scarcely perceive the sounds, but on returning home to the quietness of their rooms the sounds become very unpleasant. In other cases they are only experienced after indulgence in stimulants; after over-exertion, or mental emotion; during colds in the head, or in dull, damp weather, etc. They are sometimes associated with what is indefinitely called a "nervous state." In such cases the intensity of the symptom is more than usually modified by varying states of the nervous system, aggravated by worry or irritation, and diminished by moods of contentment and serenity. A nervous condition may, on the other hand, be excited by some of the distressing forms of this symptom. In many persons the sounds are unceasing, except during sleep. They are usually aggravated by causes which injuriously affect the hearing.

Relation of these Sounds to Impairment of Hearing. We sometimes find very distressing noises with but slight impairment of hearing. Occasionally cases are met with where the hearing is normal. In such somewhat rare cases the tinnitus aurium is probably due to reflex influences, such as from the teeth or the naso-pharyngeal mucous membrane. It is often found in such cases that *defective hearing comes on sooner or later.* More frequently, when the sounds are intense and continuous, the deafness is very considerable. Gene-

rally, if the acuteness of hearing improve, the noises diminish; while, on the other hand, with gradually advancing deafness the intensity of the sounds generally increases, until the patient may be deaf to all external sounds, while tormented by noises in his head. Sometimes, however, when a state of total deafness has been reached, the sounds completely cease, probably owing to complete loss of the functional activity of the auditory nerve.

Hallucinations of Hearing. Schwartze and Köppe have directed attention to the association of subjective sounds in the ear with *hallucinations of hearing* in the insane. Even persons who have no mental defect sometimes, for a time, confound noises in the ear, such as whistling or the ringing of bells, with actual sounds originating outside. Patients have informed the author that the sound of music was so real as to cause them to search, even by going out into the open air, for the source of it. Generally, however, a little careful observation on the part of the patient is sufficient to convince him that the sound has no existence outside his body. Von Tröltsch relates a case of melancholia with hallucinations of sound in the ear like the crying of a child. The removal of impacted cerumen was immediately attended by the disappearance of the sound as well as of the melancholia. Other cases are on record of morbid states of the mind being connected with the existence of peripheral disease of the ear causing subjective sounds. Schwartze says, "Subjective sounds in the ears, which are occasioned by undoubted disease of the ear, may, in persons disposed to psychical disease, especially where hereditary tendency to such exists, be the direct cause of hallucinations of hearing, which may provoke at any time the outbreak of pronounced mental disease." The continuous hissing, buzzing, etc., which attend the ear disease, may be associated with the hearing of "voices." Two cases are related by Köppe, in each of which only one ear was diseased, and only on that side were the "voices" heard. In these two cases, as well as in several others, the noises and hallucinations disappeared under local treatment of the ear affection.

CAUSES OF SUBJECTIVE SOUNDS IN THE EAR.

Nearly all the diseases of the ear—external, middle, or internal—may be accompanied by subjective noises. The purely subjective variety may depend upon some form of pressure or irritation applied to the auditory nerve in the interior of the cranium.

Morbid Growths or Products, such as tumours, hæmorrhagic clots, abscess, and inflammation may, by pressure upon the roots or trunk of the nerve, give rise to severe forms of tinnitus, even when the organ of hearing is unaffected.

Abnormal Pressure upon the Terminal Nerve Structures in the Labyrinth is probably the most common cause, and is exerted chiefly through the fenestræ

by pathological changes in the tympanic cavity, such as collections of exudation, swelling or thickening of the mucous membrane, or excessive pressure of the base of the stapes upon the labyrinthine fluid. Non-exudative inflammation is the most frequent and intractable cause. Here we have not only long-continued abnormal pressure upon the fluid of the labyrinth, leading often to nutritive changes in the nerve, but, owing to the rigid state of the membrane of the fenestra rotunda, which is often present, the pressure upon the fenestra ovalis has a more injurious effect upon the nervous structures of the labyrinth. The less severity and the infrequency of tinnitus in children are probably due to the yielding state of the membrane of the fenestra rotunda, and perhaps also to the wide aqueductus cochleæ which exists in the child, the bulging of the former towards the tympanic cavity, and the partial escape of the fluid of the labyrinth through the aqueduct, relieving the delicate nerve structures from the excessive pressure. In addition to pathological changes in the middle ear, excessive pressure of cerumen or of inflammatory products upon the tympanic membrane may push the ossicular chain towards the fenestra ovalis. The terminal structures of the auditory nerve may also be exposed to pressure, not only from causes existing outside of the labyrinth, but also from dilated vessels, exudations, effusions, and thickenings *within* the labyrinth. A severe and permanent form, associated at the beginning with vertigo, is due to hæmorrhagic or serous exudation into the labyrinth (see p. 352). Subjective sounds are much less frequent and severe in purulent disease of the middle ear than in interstitial inflammation.

Reflex Causes acting upon the Auditory Nerve or upon the Labyrinthine Vessels may give rise to subjective sounds. This reflex effect is frequently produced through the medium of the trigeminus nerve. Pressure or friction, either upon the mastoid process, the cheek, the tragus, or the back of the neck, may for a moment diminish or remove, or, on the contrary, may actually produce, a sound in the ear. Any irritation in the nasal or pharyngeal mucous membrane, in the gums or teeth, in the cutaneous lining of the external auditory canal, or in the mucous lining of the middle ear, may excite some form of tinnitus aurium in a reflex way by causing dilatation of the vessels of the labyrinth, or by exciting the nerve itself. It is very probable that irritation acting upon more distant parts may affect the labyrinth or nerve. Cold, for example, acting on the soles of the feet, when a person stands with bare feet on the cold ground, may excite a sounding in the ear. It is probable that there are reflex connections between the digestive organs, as the stomach, liver, etc., and the circulation in the labyrinth. We frequently see the auricle reddened from dilated vessels due to sympathetic connection, through the vaso-motor system, with other parts of the body; and the vessels of the deeper parts of the ear may have a similar sympathetic connection.

The Entotic Subjective Sounds, or those actually due to sonorous vibrations originating either within the ear or in its neighbourhood, may come from *blood-vessels*, from the *movements of secretion* in the ear, or from *muscular contraction* in the tympanum or Eustachian tube.

Vascular Sounds. *The jugular vein* under the floor of the tympanum is often the source of the sound. At that point, where the lateral sinus passes into the bulb of the jugular vein, the calibre of the venous tube becomes abruptly narrowed, and a murmur in the ear is apt to be produced at this contracted part of the lumen. We find this sound most frequently in anæmic conditions,

or when the walls of the vein have become thickened from some morbid process. A *pulsating sound* is sometimes heard in the ear owing to an abnormal state of the *internal carotid artery*, as it lies in the osseous canal in the temporal bone. This is usually caused by some obstruction to the current of blood, due to thickening of the inner coat of the artery, or to thickening of the osseous canal. Again, the dilated condition of the arterioles in congestion of the labyrinth or of the external or middle ear gives rise to a very disagreeable sense of pulsation, which is described as a *beating*, *hammering*, or *pumping* in the ear. The sounds originating in the internal carotid artery or internal jugular vein are either stopped or they are changed in character by pressure upon these trunks in the neck. Pressure upon the *posterior auricular artery* behind the ear sometimes also checks or allays these pulsating sounds. Most of these sounds connected with the blood-vessels are intensified when any impediment, such as swelling or thickening of the tympanic mucous membrane, exists to the passage of sound outwards.

Secretion in the Middle Ear often gives rise to sounds in the ear, especially during movements of the head. These are described by patients as crackling, slight splashing, or the bursting of bubbles. Creaking or rubbing movements may be heard, when excess of cerumen or a foreign body is in the outer canal of the ear.

Contraction of the Muscles of the Middle Ear is frequently attended by noises. Tonic or clonic spasm of the tensor tympani or stapedius may give rise to a slight drumming or buzzing sensation in the ear. During the contraction of the abductor tubæ in swallowing, even in a normal state of the ear, most persons are conscious of a sound. When, however, the walls of the Eustachian tube are abnormally closely connected by means of catarrhal products, a crack or such like sound often signalizes the sudden separation of the membranous wall by the action of the abductor tubæ in swallowing.

TREATMENT OF SUBJECTIVE SOUNDS IN THE EAR.

There is no actual specific remedy for tinnitus aurium. The treatment is usually that of the particular affection of the ear with which this symptom is associated, and our success will pretty much depend upon the nature of that affection. When connected with affections of the external auditory canal, with exudative catarrh, or purulent inflammation of the middle ear, the effects of treatment are usually very satisfactory. When, on the other hand, they are connected with non-exudative inflammation of the middle ear, or disease of the labyrinth and auditory nerve, the prospect of completely removing the noises is in most cases very slight. The most we can hope for, in the majority of such cases, is a certain measure of relief. This symptom is found in practice most frequently conjoined with non-exudative inflammation, and the treatment already described for that condition at p. 338 is the most generally applicable. Such treatment will frequently mitigate the symptoms temporarily or permanently, and this mitigation is usually

accompanied by improvement of hearing, although it is sometimes otherwise. When the subjective sounds are attendant upon disease of the internal ear, and this is the case with the most severe forms, the treatment described for these affections must be resorted to.

We shall here refer to the use of external applications and certain special internal medicines, as well as to one or two points in general treatment.

Counter-Irritation behind the ear has, in some cases, a mitigating influence on the noises. This may consist of vesication, or the application of the tincture or the ointment of iodine or iodide of potassium (Formula 33), or of a spirituous embrocation (Formula 68) employed over the mastoid process.

Politzer speaks favourably of repeatedly painting the cartilaginous part of the external auditory canal, especially when there is abnormal dryness of the meatus, with Formula 72. While some patients state that they find partial relief to the sounds from pouring warm water or warm diluted glycerine into the ear, the pouring of fluids into the interior of the ear is generally useless and may be injurious.

The subcutaneous injection of morphia into the back of the neck is sometimes resorted to, with temporarily good effect, in very violent and paroxysmal noises.

The Vapour of Chloroform or of Sulphuric Ether inflated through the Eustachian catheter (see p. 73) has sometimes a mitigating influence upon severe tinnitus.

Ligaturing the Carotid or Posterior Auricular Artery has been proposed in those cases of extremely distressing sounds, which are removed by pressure on either of these vessels.

Hydrobromic Acid (Formula 141), suggested at first by its effect in counteracting the aural symptoms produced by quinine, has been much advocated by Dr. Woakes, especially for vascular tinnitus, on the theory that it leads to contraction of the labyrinthine vessels. The effects of this drug are often disappointing, and the author has found it more useful in cases associated with vertigo (Ménière's disease) than in other forms of tinnitus.

Bromide of Potassium or **Bromide of Sodium** is often of service in cases associated with great irritability of the nervous system. From thirty to sixty grains dissolved in a large quantity of water every evening have often, for a time at least, a distinctly alleviating influence upon severe tinnitus.

Chloride of Ammonium in twenty grain doses, three times a day, was proposed and strongly recommended by Hinton. When useful, which, in the experience of the writer, is but seldom, its effects are probably due to its action on the naso-pharyngeal mucous membrane.

Salicylate of Sodium in fifteen grain doses, thrice daily, has been spoken of favourably by some writers, especially in the subjective sounds of Ménière's disease.

Digitalis may be tried in the severely pulsating form, due to some morbid condition of the blood-vessels; it has in some cases a mitigating effect.

On the merits of nitrite of amyl, strychnine, arsenic, nitro-glycerine, convallaria, tincture of arnica, valerianate of zinc, etc., we need not descant. To discuss the merits of the multifarious medicinal remedies suggested for the

relief of noises in the ear would neither be profitable nor interesting. The aural practitioner unfortunately has been too often impressed with their feebleness and inefficiency. They may be tried when other measures are without effect.

Electric Treatment may sometimes prove beneficial from the action of the electricity upon the intrinsic muscles of the middle ear. We know the far-reaching influences of disturbance of the muscular apparatus of the middle ear upon the tension of the tympanic structures, and, secondarily, upon the tension of the labyrinthine fluid. The author has consequently seen better results from the faradic current (see p. 80) than from the constant current. On the whole, however, the effects of electric treatment of tinnitus aurium are generally disappointing.

Tone Treatment. Lucæ of Berlin observed that a striking influence was exerted upon certain subjective sounds, of a musical character, by bringing to bear upon them objective sounds coming from a tuning-fork, especially if these be as far removed as possible in pitch from the subjective ones. For example, if the sounds in the ear are high-pitched notes, such as hissing, ringing, and whistling, a deep-toned tuning-fork (such as C or C_1) is employed; on the other hand, if the sound be low-pitched, such as rushing, buzzing, humming, or a low-toned bell, then a tuning-fork of a high pitch (such as C^3 or C^4) is used. The vibrating fork is applied either by placing the end of its handle into the external meatus, or, in order to augment the sound, the vibrations are passed through a resonator fixed into the orifice of the ear. The duration of the application may extend from one minute to five minutes, and, in order to ensure a continuous sound, the tuning-fork may be connected with a magneto-electric apparatus. The author has found from this method of treatment a temporary diminution or even disappearance of the sound, the respite varying from five minutes to several hours. He has not yet found a case in which a permanent effect was produced.

Pilocarpine, applied hypodermically, is useful in a limited number of cases, especially, as Politzer first pointed out, in recent exudation into the cavities of the labyrinth (see p. 365). Its action is probably due to its stimulating effect on the absorbents in contact with the effused products before these have become organized. This resorbent effect has probably some connection with its remarkable powers of exciting the cutaneous and salivary secretion.

General Treatment of Subjective Sounds. In the treatment of the persistent forms of subjective sounds in the ear, *the state of the whole body* should come under review, and appropriate medicinal, hygienic, or dietetic treatment should be employed to rectify, if possible, any departure from the healthy condition. The use of cathartics or mercurial preparations is in some cases very efficacious in giving relief, for a time at least, to the patient's distress. Some patients say that after a dose of Gregory's mixture, or a blue pill, followed by a saline, they enjoy a day or two's respite from the noises. If the hepatic functions are disturbed, and a torpid state of the bowels exists, a course of aperient waters, especially Carlsbad, or its salts in the finely powdered form, with an occasional mercurial, may temporarily relieve, if not altogether remove, the tinnitus (see General Formulæ).

CHAPTER XVIII.

DEAF-MUTISM.

Dumbness must not be looked upon as a separate or isolated disease. It is, in the vast majority of cases, simply *a consequence of total, or of a high degree of, deafness*, which has either been congenital, or has originated in the early years of life. Deafness for speech coming on under four years of age is certain to be attended by dumbness; and even between four and eight years of age, if great care is not exercised, and especially if the child has not learnt to read, or is of less than average intelligence, serious deafness is liable to be followed by loss of speech.

The deafness, which leads to mutism, may be *congenital* in its origin, or it may be *acquired* after birth.

Congenital Deaf-Mutism. Recent investigation seems to prove that the *congenital* form is somewhat less frequent than the acquired. The pathological conditions found in the congenital form are either defective formation of the ear, such as closure of the external auditory canals, absence of the fenestral openings, or partial or complete absence of the semicircular canals; or they are the results of intra-uterine inflammation of the labyrinth or middle ear. Sometimes, however, no pathological change can be discovered in any part of the ear. Hereditary influences probably play an important part in the production of these defects or diseases. It is somewhat remarkable, however, that only a very small proportion of the children of deaf-mutes have the affliction of their parents. On the other hand, several members of a family may be deaf-mutes, and yet no defect of hearing exists in either of the parents. Indirect transmission of hereditary tendency to deaf-mutism seems to be much more frequent than direct. It is more common to find that the uncle or grand-uncle has been a deaf-mute, than the father or grandfather. The inter-marriage of relatives is said to be productive of a large number of deaf-mutes. According to Hartmann 8·1 per cent. of deaf-mutes are the offspring of consanguineous marriages.

Some authorities, on the other hand, deny this. Probably these marriages are liable to produce defects in the descendants, only when serious constitutional anomalies exist in the family from which both parents spring, in which they would both share. The probability is that, when the lineage of the two is healthy, the offspring does not suffer from the relationship of the parents.

In the Acquired Form of Deaf-Mutism, that is, where the deafness causing the mutism has originated after birth, the pathological conditions are very various. They are frequently in the labyrinth or nerve of hearing, and are the sequelæ of cerebral diseases, of *cerebro-spinal or ordinary meningitis*, of inflammation of the labyrinth, syphilis, injuries, mumps, scarlet fever, typhus fever, measles, diphtheria, etc. Pathological changes are not unfrequent also in the middle ear, as the consequences of catarrhal or inflammatory diseases. The most common are thickening or rigidity of the fenestral membranes, extensive adhesions, anchylosis of the stapes, and other effects of adhesive catarrh. At other times we find, owing to purulent inflammation, destruction of the tympanic membrane and ossicular chain. In all these cases, both ears must be seriously affected before leading to such a degree of deafness as to hinder the hearing of loud speaking. Hereditary influence probably also plays a part in the causation of the acquired form.

It is useful to recognize two forms of acquired deaf-mutism. First, when the deafness arises so early in life (in the first year or two years), that the child has never spoken. It is evident that, if he does not hear words, he cannot learn to speak. Second, where the deafness affects the child after the power of speech has been partially or completely acquired, depriving him of speech. This may happen up till the seventh or eighth year of life.

Deafness less disastrous in the Adult than in the Child. A degree of deafness, which would rob the child of speech, or which would prevent him acquiring it, would probably in the adult interfere very little with his social intercourse. The adult, who becomes very deaf, retains his power of speech, because (1) it is so firmly implanted in his memory that he can never forget it; (2) his knowledge of language, and of the lip and facial movements made in speaking, enables him to guess, from the words which he does hear, the sense of those he fails to hear, and also to partially understand what is said from the visible movements of the lips; (3) he insists on hearing and understanding by asking the speaker to articulate loudly and distinctly; and (4) his ability to read maintains and even extends his knowledge of language.

Serious Effects of Deafness in Childhood. *It is very different with the young child,* who has only recently acquired, and that very

partially, a knowledge of spoken language. For years this knowledge remains very limited and defective. His knowledge of the various and multiform sounds, with their meanings, which constitute spoken language, is attained very gradually and slowly, by frequent repetition of words in the hearing of the child, in conjunction with the exhibition of the objects, qualities, or actions, which they represent. With a healthy mental condition and a normal state of the vocal organs (the latter are very rarely abnormal) the naturally strong imitative faculty of a child enables him to repeat the sounds, at first imperfectly; gradually, as he repeatedly and accurately hears the same sounds, his intonation and pronunciation become more and more perfect. But, when the hearing of words becomes distinctly impaired, although far from being totally lost, a less perfect articulation is very early observed, as he fails to hear all the shades of sound which make up articulate speech.

The Proportion of Deaf-Mutes to the Population, so far as statistical investigation informs us, is 7·77 to every 10,000. In Great Britain the proportion is 5·70 to the 10,000. In mountainous districts the proportion is very much greater than in the plains. In Europe the largest number is in Switzerland, where there are 24·5 deaf-mutes for every 10,000 of the population. The Netherlands show the smallest proportion, 3·35 in the 10,000. It is conjectured that the excess in the mountain districts is due to the greater tendency in these regions to consanguineous marriages.

Diagnosis of Total Deafness in the Child. If a dumb child is brought before us for the first time, after the age at which speech should begin to be acquired, it is difficult to ascertain with certainty whether the child ever had the power of hearing. Parents are very unwilling to think that their child has never heard. Besides, it is not easy to determine positively, in the first year of life, especially in the first few months, whether a child hears. The mother may find that the child sleeps more soundly, and is found to be unaffected by noises which disturb and waken other infants. But at this age, if we find the organs to be normal, so far as they come under objective examination, we cannot arrive at certainty. We shall often find by objective examination pathological states of the tympanic membrane, such as chalky deposits, indrawn membrane, cicatrices, or even perforations. These are in most cases merely accidental, having nothing to do with the serious deafness, the causes of which are more deeply seated. After the first year, it is generally possible to determine whether or not marked deafness exists. The mother's anxiety is aroused by *the delay of the child in beginning to speak*, and by its inattention to loud sounds produced in its neighbourhood. Suspicion being excited, the child should be

tested in various ways. While its eyes are turned away from the source of sound, a bell or whistle is sounded, or the hands are clapped, or vowel sounds are loudly pronounced. If the attention of the child is not excited, as shown by the head not being turned round towards the source of the sound, it may be concluded that there exists no actual power of perceiving sound. It is well that such tests should also be applied by the parents at home. In testing the child's power of perceiving the tuning-fork through the bones of the head or near the ear, we should first apply the tuning-fork to the forehead or near the ear, while it is silent, when the child's features will probably remain impassive; but, if applied afterwards while vibrating, the child's smile, or cry of surprise, will inform us that he hears the sounding fork. In this way we may generally ascertain the power of hearing a tuning-fork possessed by a child over two years of age.

Some modicum of hearing is possessed by a large number of deaf-mutes, probably by 75 per cent. Loud, sharp sounds are most frequently heard, or the loud pronunciation close to the ear of vowel sounds. In a smaller number complete words are heard when shouted loudly into the ear. The use of the hearing tube may be in these cases of great service, and should be utilized in the instruction of deaf-mutes in articulate speech.

Without Training or Education, deaf-mutes are apt to become extremely violent and possessed of little self-restraint. Their tempers are often ungovernable, and their passions uncontrolled.

The prognosis of the deafness in deaf-mutism is very unfavourable. If the middle ear be diseased, suitable treatment may improve the hearing. In Politzer's experience deaf-mutism from congenital causes is more hopeful than total deafness, if acquired. He has seen a number of cases of total deafness, of a congenital nature, during the first few years of life, in which ultimately partial, and in one case complete, hearing existed. The author has not seen a single case of improvement in cases due to meningitis, probably the most frequent cause of the acquired form.

TREATMENT OF DEAF-MUTISM.

We shall consider this under two heads: (1) The medical treatment, and (2) the educational treatment.

The Medical Treatment is mainly suitable for the acquired form of deaf-mutism, and may in these cases be of the greatest value. The ear and the naso-pharynx should be carefully examined, and, if any disease exist, appropriate treatment should be employed.

When, for example, exudative catarrh or chronic purulent disease of the middle ear is associated with the deafness, there is great hope of improving the hearing power with possibly subsequent partial recovery of speech. If post-nasal growths be found, their removal may improve the hearing, and will, in any case, improve the breathing and general condition of the child. Every aural surgeon meets with cases now and again of delay in learning to speak, or of loss of speech in the young child, due to such remediable causes, where the child was much improved, and even rescued from what appeared to be pronounced deaf-mutism. In the congenital forms, and also in the acquired, when due to an obscure condition of the internal ear, galvanism by the continuous current may be tried. If greater attention were given to the treatment of diseases of the ear in childhood, mutism might in some cases be averted or cured.

The Educational Treatment of Deaf-mutes is a most interesting subject, which has of late years received great attention.

Prevention of Dumbness. We shall first look at the efforts which should be carried out to prevent dumbness in children whose hearing is not completely lost. When a young child, who has commenced to speak, becomes deaf to the extent of not hearing words spoken in an ordinary tone of voice, he drifts gradually into mutism. In order to avert this, most diligent and painstaking efforts should be made to maintain his knowledge of spoken words, and even to add to his stock of them. A considerable amount of time should be devoted daily to speaking slowly, clearly, and in a sufficiently loud tone close to the ear of the child, who must also be made to repeat the words frequently. When the deafness is very marked, the aid of a hearing tube may be of service. In the severe forms, instruction in lip-reading should also be carried out, and, by utilizing what hearing there is, the modulation and pronunciation may be corrected and improved. By efforts of this kind we may in some cases prevent the child lapsing into dumbness, and at the same time prevent that injury to the mental faculties which is likely to result from his being partially or wholly shut out from spoken language at the most valuable educational period of life. We would here point out the importance of giving special attention to school children who may suffer from defective hearing. The author has found, as the result of the examination of a large number of school children, that 27 per cent. suffered from diminished hearing. Many children are regarded as stupid or inattentive, when defective hearing is the *real cause* of their seeming stupidity or inattention. When the hearing of a child attending school is found to be imperfect, he should occupy a place near to the teacher, and

should otherwise receive special attention. It would be an advantage if there were institutions or schools, *distinct from ordinary deaf and dumb institutions*, where *partially* deaf children might be trained and educated, with special regard to their defects and wants.

There are two systems now in use for the education of deaf-mutes: (1) *The French system*, by the manual alphabet and signs —*Dactylology*; (2) *the German system*, by lip-reading and articulate speech.

Manual Signs and Gestures. This system, which is based upon the natural tendency, has hitherto been practised in the institutions for the deaf and dumb, and it has been a great blessing to deaf-mutes. It is improbable that the system of lip-reading will ever entirely supersede this old method of communicating by visible signs.

Lip-reading and Articulate Speech. Nearly all persons, suffering from dulness of hearing, instinctively and almost unconsciously read the face of the speaker. They hear with the eye, as an old authority has it, and are often astonished at their apparently greater deafness in the dark or when their eyes are shut. Children are sometimes brought, whose parents suppose them to be suffering from simple dulness of hearing with indistinctness of speech, but who, on examination by the aural specialist, are found to be almost totally deaf. Their power of lip-reading and speech, owing to a natural aptitude, has been such as to deceive the parents, who are dismayed at the serious character of the deafness of their child when tested with the eyes blindfolded. It is, however, very important to remember that the perfection of speech and lip-reading attained by this method varies very much according to the intelligence and aptitude of the child, the qualifications of the teacher, the age at which it is commenced, the length of time during which it is carried on, and *whether or not the child possesses any modicum of hearing*. There is no doubt there are some deaf-mute children, who, although free from any mental defect, lack the intelligence and quickness necessary to make them proficient in lip-reading or in articulation. The qualities of the teacher have also a great influence on the results. He should be actuated by enthusiasm in his calling, and possessed of a painstaking perseverance of no ordinary kind, besides having received a thorough training in all the details of the system. It is of importance that the child should begin early—in the seventh year, if possible—and that the teaching should extend over ten or twelve years. If the child possess a small amount of hearing, so as to distinguish words or vowels loudly spoken into the ear, the modulation and pronunciation

can be made much more natural than in the totally deaf child, whose pronunciation has usually a disagreeable harshness. Probably in some cases the use of the hearing tube would assist in utilizing any modicum of hearing power remaining, not only by enabling the child to hear the teacher's voice, but also by correcting his own articulation, when speaking or reading into the tube while the latter is inserted into his own ear.

The Combined Methods. Some authorities recommend the use of *dactylology* in conjunction with the oral method, during the first year or two, as facilitating the acquirement of the meanings of words, while others put great stress upon the importance of *entirely excluding* manual signs as a condition of success with the German method. The present tendency of opinion among those who have great experience in the education of deaf-mutes is in favour of the old method by signs combined with the new method when practicable. For the great majority of deaf-mutes a knowledge of the old method is essential; but when the necessary amount of time, aptitude, and intelligence is available, instruction in lip-reading and articulate speech will prove a great advantage. It is right to say that probably no one has ever by the new method acquired the power of following an ordinary public speaker.

Instruction in Lip-reading by Adults is perhaps not sufficiently taken advantage of. In the case of adults who have become totally deaf after the age of childhood, and who, though able to talk themselves, can make out very little of what is spoken by others, it might prove of considerable advantage if they received methodical instruction from qualified teachers in lip-reading.

In order that deaf-mutes belonging to the humbler classes may derive the advantage of being instructed on this system, recent legislation has very properly extended grants to School Boards to meet the additional expense in educating deaf-mutes, to whom are now extended for the first time the privileges of the Education Act. As it has been found that a considerable number of deaf-mute children will never acquire, owing to lack of aptitude, any useful power of lip reading or articulate speech, it would economize teaching power if, after a period of probation, such children were separated from those receiving instruction in the new method who showed proper aptitude.

APPENDIX.

I.

OTALGIA.

Pain is not unfrequently complained of in the ear, when objective examination shows no inflammatory process to be present. The pain is usually sharp and darting, disappearing and recurring, sometimes at regular but more commonly at irregular intervals. In this intermittent way otalgia may prove troublesome for days, months, or even years. It is in some cases simply a part of a general neuralgic affection of the fifth nerve. It is frequently also reflex in its character, as in caries of the teeth, ulceration of the pharynx or larynx. Pressure upon the nerves, either inside or outside the ear, also excites otalgia. In the ear the pressure may be exerted by catarrhal thickening of the mucous membrane, which may excite pains in the side of the head. The pain is in some cases, though not commonly, localized in the auricle. It most frequently, however, affects the tympanic plexus (glosso-pharyngeal and trigeminus) in the mucous lining of the tympanum. It is to be remembered that inflammation in the middle ear is not unfrequently regarded by medical men as neuralgia, if no objective examination be employed. As in the case of neuralgia elsewhere, it may here be caused by anæmia, syphilis, or the action of cold.

Treatment. Vesicants behind the auricle are often useful. The application to the neighbourhood of the ear of a sedative liniment (Formula 73) is generally attended by relief, or a few drops of the sedative liniment, on a plug of cotton inserted into the external meatus, may prove more useful. The subcutaneous injection of morphia may be required in intense and persistent forms. *The teeth should be examined*, and, if caries with pain on pressure be discovered in a tooth, it should be extracted or stopped. Galvanism may be effective in removing neuralgia, which has resisted every other method of treatment.

Large doses of quinine (Formula 146) should be tried ; its combination with iodide of potassium, especially if syphilis is suspected, may be of great advantage. If the patient be anæmic, iron or arsenic (Formula 114) should be prescribed, along with nutritious food and fresh country air.

II.

NERVOUS AND VASCULAR SUPPLY OF THE EAR.

(*a*) Nervous Supply of the Ear.

The sensory nerves supplying the various parts of the ear are derived from : (1) The great auricular from the cervical plexus ; (2) the pneumo-

gastric; (3) the third division of the fifth cranial nerve; (4) the glosso-pharyngeal; (5) the large and small superficial petrosal nerves.

1. The *great auricular nerve* supplies the posterior part of the auricle, the outer surface of the lobule, and a small part above the lobule, as well as the integument over the mastoid process.

2. A twig, the nerve of Arnold, is given off from the jugular ganglion of the *pneumogastric*, pierces the bone, is distributed chiefly to the skin of the posterior wall of the external canal of the ear, and joins the facial nerve behind the auricle. This share of the pneumogastric in the innervation of the canal of the ear accounts for certain reflex phenomena, such as coughing, etc., not unfrequently observed when the canal of the ear is touched with a speculum or other instrument, or pressed upon by a foreign body.

3. The *third division of the fifth cranial nerve* gives off the auriculo-temporal, which distributes branches to the outer surface of the auricle, to the walls of the external auditory canal, and to the outer layer of the tympanic membrane. The ramifications of this nerve impart to the canal of the ear and to the dermoid layer of the tympanic membrane their acute sensitiveness.

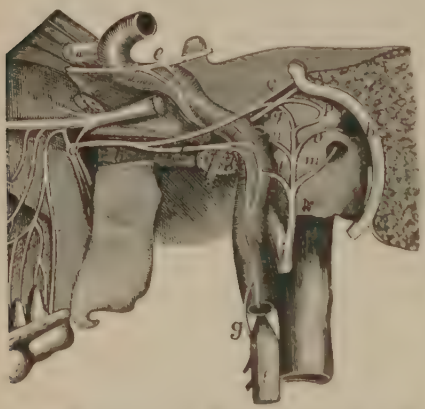

FIG. 229. View of the tympanic plexus of nerves (after Hirschfeld and Leveille). *a*, Spheno-palatine ganglion; *b*, Vidian nerve; *c*, great superficial petrosal nerve; *d*, carotid branch of the Vidian nerve; *e*, part of the sixth nerve, connected by twigs with the sympathetic; *f*, superior cervical ganglion of the sympathetic; *g*, carotid branch; *h*, facial nerve; *i*, glosso-pharyngeal nerve; *k*, nerve of Jacobson; *l*, its twig to the sympathetic; *m*, filament to the fenestra rotunda; *n*, filament to the Eustachian tube; *o*, filament to the fenestra ovalis; *p*, union of external deep petrosal nerve with the lesser superficial petrosal; *q*, internal deep petrosal twig uniting with the great superficial petrosal.

4. The *glosso-pharyngeal nerve*, by means of Jacobson's nerve branching off in the jugular fossa, has the most important share in forming the tympanic plexus, which occupies the grooves on the inner wall of the tympanum, and supplies the lining of the middle ear with sensation. In making applications to the inner wall of the tympanum, patients not unfrequently feel as if the throat were touched, which is due to this twig from the glosso-pharyngeal nerve.

5. The *large and small superficial petrosal nerves*, from the spheno-palatine and the otic ganglion respectively, are connected with the tympanic plexus.

The *tympanic plexus* (Fig. 229) is made up of—(1) Jacobson's nerve; (2) twigs from the sympathetic plexus surrounding the carotid artery in its canal; (3) a communication with the great superficial petrosal nerve (a branch which connects the Vidian nerve, from *Meckel's ganglion*, with the facial nerve in the Fallopian canal); (4) the small superficial petrosal nerve, which connects the nerve of Jacobson with the otic ganglion and the facial nerve.

The *chorda tympani* nerve gives off no branch to the tympanum, merely passing through that cavity. If the view, held by some anatomists, that its fibres are really a continuation of the large superficial petrosal nerve, is correct, there is a connection between the chorda tympani and the plexus supplying the middle ear. The position of the chorda tympani on the inner surface of the tympanic membrane probably accounts for the anomalies of taste, sometimes

found in patients suffering from chronic purulent inflammation of the middle ear, and also for peculiar sensations in the tongue, sometimes excited when the nerve is touched with a probe.

The motor nerves supplying the muscles of the ear are derived from the following sources, and have the following distribution:

1. The muscles of the auricle are supplied chiefly by the posterior auricular and temporal branches of the facial nerve. 2. The tensor tympani and the abductor tubæ receive their nervous supply from the otic ganglion through the nerve to the internal pterygoid from the motor root of the fifth nerve. 3. The stapedius is supplied by the facial nerve. 4. The levator palati is supplied by the pneumogastric, and, according to some authorities, also by twigs from Meckel's ganglion.

The *otic ganglion*, situated at the outer part of the cartilaginous Eustachian tube, controls and regulates the reflex and sympathetic relations of the different parts of the organ of hearing to one another, and to near or distant regions of the body. This ganglion is formed of: (1) Motor and sensory fibres from the third division of the fifth cranial nerve, namely, the internal pterygoid and the auriculo-temporal nerves; (2) fibres from the sympathetic round the middle meningeal artery: (3) fibres from the glosso-pharyngeal and facial nerves through the small superficial petrosal.

The otic ganglion also gives off branches to supply the tensor tympani and abductor tubæ muscles. This ganglion is thus connected with the nerves which supply the various parts of the external and middle ear. In this way also, from a distant centre of irritation, such as the teeth, vaso-motor changes are produced through the sympathetic, leading to dilatation of vessels and ultimate inflammation in the linings of the ear, or in the labyrinthine blood-vessels.

(*b*) Vascular Supply of the Ear.

1. **The arterial supply** of the external and middle ear is derived almost altogether from the *external carotid artery*. Only one or two twigs are given off by the *internal carotid*, in the carotid canal, to a part of the Eustachian tube and tympanum. The following are the branches and terminal divisions of the external carotid supplied to the different sections of the ear.

a. The *posterior auricular artery* supplies chiefly the inner surface of the auricle, and partially the external auditory canal. It gives off the stylo-mastoid artery, which is distributed to the neurilemma of the facial nerve, to the mastoid cells, and to the posterior part of the tympanum and stapedius. A few twigs also penetrate the inner wall of the tympanum to the labyrinth, and anastomose with the internal auditory artery.

b. The *occipital artery* provides an auricular branch to the back of the concha.

c. The *temporal artery* gives off the anterior auricular to the fore-part of the auricle, to the lobule, and a small part of the external auditory canal.

d. The *internal maxillary artery* provides several branches to the ear—1. The deep auricular, supplying the tragus, the deep parts of the external auditory canal, and the outer layer of the tympanic membrane. The chief branches to the membrane pass down from the roof of the canal. 2. A tympanic branch is sent off, chiefly to the inner layer of the membrane. 3. From the middle meningeal the petrous branch penetrates to the tympanum and Eustachian tube, through the hiatus Fallopii and petro-squamosal fissure. 4. The Vidian sends small branches to the Eustachian tube and tympanum.

c. The *ascending pharyngeal artery* supplies small twigs to the Eustachian tube and tympanum.

2. The internal ear receives its chief vascular supply from the *internal auditory artery*, a branch of the basilar. A few twigs are provided by the stylo-mastoid artery, by which also the circulation of the external and middle ear is connected with that of the internal ear.

The venous blood from the external and middle ear is discharged partly into the external and partly into the internal jugular veins, by means of branches corresponding to the arteries.

The venous blood from the labyrinth is discharged by the superior petrosal sinus into the lateral sinus.

FORMULÆ OF REMEDIES RECOMMENDED IN THE COURSE OF THIS WORK.

A.—LOCAL REMEDIES.

I. Nasal Inhalations.
II. Ointments.
III. Powders.
IV. Pigments for Throat.
V. Gargles.
VI. Lozenges.
VII. Embrocations and Counter-Irritants.
VIII. Solutions employed as "Ear Drops."
IX. Solutions for applying to Middle Ear through Eustachian tube.
X. Solutions suitable for Syringing the Ear.
XI. Solutions suitable for Syringing the Nose.
XII. Caustics.

B.—GENERAL REMEDIES.

I. Remedies for Anæmic or Tubercular conditions.
II. Remedies for Syphilitic conditions.
III. Remedies for Dyspeptic, Gouty, or Lithæmic conditions.
IV. Diaphoretics, Sedatives, Febrifuges.
V. Remedies chiefly employed for the Relief of Subjective Sounds in the Ear.

A.—LOCAL REMEDIES.

I. Nasal Inhalations.

I. Steam Inhalations. The medicaments should be added to water at a temperature of 140° F. In inhaling, an india-rubber nasal piece is placed over the mouthpiece of an ordinary inhaler; or inhaling the vapour from a narrow mouthed jug may suffice. The following are employed in the proportion of a teaspoonful to a pint of water. They are useful chiefly in acute rhinitis (see p. 124).

1. ℞ Tinct. Benzoin. Co. ℥ij.

2. ℞ Sp. Camphoræ ℥ij.
   Sp. Vini Rect. ℥vj.
   Aquæ *ad* ℥ij. M.

3. ℞ Glycer. Acidi Carbolici ℥ij.

4. ℞ Ol. Eucalypt. ℥j.
   Menthol. gr. xl.
   Sp. Chloroformi ℥ij.
   Sp. Rectif. *ad* ℥ij. M.

5. ℞ Acid. Acetici ℥ij.

II. Dry Inhalations.

6. ℞ Acid. Carbolic. ℥j.
   Alcohol. Ethylic. ℥iij.
   Liq. Ammon. Fort. ℥j.
   Aquæ ℥ij. M.

"Hagar's Anti-catarrhal Mixture." To be kept in a glass-stoppered dark bottle.

Sig.—A few drops are poured on the inner surface of a cone of blotting paper, this is held to the nose while the patient —whose eyes should be closed—inspires deeply as long as vapour is given off. The process may be repeated every two hours.

Use—Beneficial in acute rhinitis.

7. ℞ Menthol. gr. xl.
Ol. Eucalypti } āā ʒj.
Ol. Terebinth. }
Æther. } āā ʒiv. M.
Sp. Vini Rect. }

Sig.—May be employed as above, or inhaled from a few drops sprinkled on the palms of the hands (Dr. Newman).

8. Menthol is conveniently used for nasal inhalation by means of Maw's Menthol Inhaler. Eucalyptus or Pine oil may be added by pouring a few drops on the cotton in the tube. Wool impregnated with 5 per cent. of Menthol may be usefully inserted into the nostrils.

9. Ammonii Chloridum.

Conveniently produced and applied in its nascent state by means of Burroughs' or Godfrey & Cooke's Inhalers.

Use—Employed in acute or chronic rhinitis, especially when associated with middle ear catarrh.

10. Vapor Iodi.

Small portions of Iodine are placed in a quill with cotton above and below, and while it is partially volatilized by the heat of the hand the fumes are sniffed into each of the nostrils.

Use—In nasal catarrh.

III. Atomized or Spray Inhalations.

In addition to the following Formulæ, all the solutions used for syringing the nose (Nos. 102 to 109) may be employed in form of spray.

11. ℞ Liq. Morphinæ Hydrochlor. ʒij.
Aquæ ʒij. M.

Use—A teaspoonful introduced in the form of spray into the nasal passages sometimes cuts short rhinitis at the early stage.

12. ℞ Menthol. gr. xl.
Paroleine (vel Vaselini Fl.) ʒij. M.

Sig.—To be sprayed into the nose by means of the Paroleine Atomizer (see p. 131). Eucalyptus and other medicaments may be used in the same manner (see p. 130).

13. ℞ Cocaine gr. xij.
Acidi Salicylici gr. ij.
Aquæ ʒiv. Solve.

Use—In acute rhinitis, or as preliminary to operations on the nasal mucous membrane.

14. ℞ Spirit. Rectif. ʒij.

Use—For roots of nasal polypi, beginning with one of rectified spirit to five of water, and increasing the strength as patient can comfortably bear it.

15. ℞ Glycerini Acidi Tannici ʒi.

Sig.—A teaspoonful to be added to four ounces of tepid water.

II. Ointments.

16. ℞ Hydrarg. Oxid. Rub.
Hydrarg. Ammoniat. āā gr. vj.
Adipis Benzoat. ʒj.
Ol. Olivæ Opt. ʒij. M.

Use—For dry, scaly eczema of the auricle; also for eczematous thickening of external meatus, when the ointment is applied on cotton plugs.

17. ℞ Hydrarg. Oxid. Rub. gr. iv.
Ol. Rusci ♏vj.
Vaselini ʒj. M.

Use—Same as preceding Formula.

18. ℞ Ung. Diachyl. ʒj.

Use—In the more acute forms of eczema, when the parts are to be frequently anointed and the ointment kept constantly applied on a piece of soft rag.

19. ℞ Ung. Zinci Oxid. ʒvj.
Liniment. Calcis ʒij. M.

Use—In eczema of the auricle; also in eczematous conditions inside the nostrils.

20. ℞ Liniment. Calcis
Ung. Hydr. Nitratis āā ʒjss.
Liq. Carbonis Detergent. ♏xij.
Ung. Zinci Oxid. *ad* ʒj. M.

Use—For chronic scaly eczema of the auricle or external auditory canal; may be brushed over the parts.

21. ℞ Ung. Iodoformi ʒj.

Use—For applying with friction to mastoid process in syphilis of labyrinth.

22. ℞ Ung. Hydrarg. ʒj.
Use—Same as last Formula. Rubbed into the inside of the arms and thighs, it is employed for its constitutional anti-syphilitic effect.

23. ℞ Ung. Iodi ʒj.
Use—For applying to mastoid process in thickening of the tympanic membrane (Wilde); also in chronic suppurations of middle ear if the patient is syphilitic or scrofulous. In milder cases of mastoid periostitis, and in disease of the labyrinth, it is sometimes useful when applied behind the auricle.

24. ℞ Ung. Picis
„ Zinci Oxid. āā ʒiv. M.
Use—In dry or scaly eczema of the auricle; brushed over the parts.

25. ℞ Acid. Borici gr. xx.
Vaselini ʒj. M.
Use—For painting walls of external meatus in cases of furunculi; also in eczema of auricle.

26. ℞ Menthol. gr. ij.
Iodoformi gr. iv.
Lanolini ʒij.
Vaselini Fl. ʒij. M.
Use—Applied on cotton plugs inserted into external meatus in cases of boils; also to simple abrasions or ulcerations inside nostrils.

27. ℞ Morphinæ Acetat. gr. i.
Vaselini ʒj. M.
Use—For anointing walls of external meatus, when there are boils or other painful inflammations.

28. ℞ Ung. Atropinæ ʒj.
Vaselini ʒiij. M.
Use—Applied to nasal mucous membrane in excessive watery discharge from the nose.

29. Ung. Eucalypti.
Use—Applied to nasal mucous membrane for dry conditions.

30. ℞ Menthol. gr. ij.
Cocainæ gr. iij.
Vaselini ʒj. M.
Use—Valuable in acute rhinitis and after cauterization of the nasal mucous membrane.

31. ℞ Bismuthi Subnitratis (vel Oleatis) gr. xx.
Adipis Benzoat. ʒiv.
Vaselini ʒiv. M.
Use—For applying to eczematous surface of auricle.

32. ℞ Ichthyol. gr. xij.
Lanolini ʒij. M.
Use—Same as preceding Formula.

33. ℞ Potass. Iodidi gr. xxx.
Camphoræ gr. vj.
Ol. Menth. Pip. ♏v.
Ung. Simpl. ʒiv. M.
Use—Applied with friction to mastoid surface for the relief of tinnitus aurium (Gruber).

34. ℞ Cocainæ gr. iij.
Vaselini ʒi. M.
Use—Same as Formula 30.

35. ℞ Ung. Acidi Salicylici ʒiv.
Use—In pruritus of the external meatus.

36. ℞ Ung. Hydrarg. Oxid. Rub.
Ung. Hydrarg. āā partes æquales q. v. M.
Spread on plaster 2½ ins. × 1 in.
Use—When applied over the mastoid for a night it is said to act beneficially in cases of periostitis.

III. Powders.

37. ℞ Morphinæ Hydrochloratis gr. ij.
Bismuthi Subnitratis ʒvj.
Pulv. Acaciæ ʒij. M.
Use—"Ferrier's Snuff." Insufflated into the nose in acute rhinitis.

38. Menthol. gr. x.
Pulv. Acidi Borici (vel Pulv. Cetacei) ʒiv. M.
Use—Same as preceding Formula.

39. Menthol. gr. x.
Cocain. Hydroch. gr. x.
Pulv. Acidi Borici (vel Pulv. Cetacei) ʒiv. M.
Use—Same as preceding Formula, especially when great sense of nasal obstruction.

40. ℞ Pulv. Amyli ʒiij.
Zinci Oxidi ʒj.
Calaminæ ʒss. M.

Use—For dusting parts in acute eczema of auricle.

41. ℞ Acid. Borici Calend.[1] ʒiv.

Use—Invaluable in acute and chronic purulent inflammation of the middle ear (see p. 249).

42. ℞ Acidi Borici ʒiij.
Iodoform. ʒj. M.

Use—In certain forms of purulent middle ear disease (see p. 252).

43. ℞ Acidi Borici Calend.[1] ʒiv.
Acidi Carbolici gr. x. M.

Use—Recommended by Politzer for insufflation in purulent middle ear disease associated with great fetor of the discharge.

44. ℞ Acidi Borici Calend.[1] ʒiv.
Acidi Salicylici gr. x. M.
Use—Same as preceding Formula.

[1] Boric Acid impregnated with a Tincture of *Calendula officinalis*.

IV. Pigments for Throat.

Suitable in cases of congestive swelling and general thickening of the pharyngeal mucous membrane, or in granular pharyngitis. The throat should be painted once or twice daily.

45. ℞ Iodi gr. vj.
Potass. Iodidi gr. xij.
Acidi Carbolici gr. xv.
Ol. Menth. Pip. ♏v.
Glycerini ʒj. M.

46. ℞ Ferri Perchlorid. ʒj.
Aquæ ʒj. Solve.

47. ℞ Glycerin. Acid. Tannic. ʒiv.

48. ℞ Tinct. Iodi ʒiv.

49. ℞ Glycerini Acidi Tannici ʒij.
Glycerini Acid. Carbolic. ʒij. M.

V. Gargles.

Employed in "relaxed," swollen, or softened states of the mucous membrane of the throat. *They may also be used in form of spray.* For proper mode of gargling see p. 146.

50. ℞ Boracis ʒij.
Acidi Carbolici gr. xvj.
Glycerini Puri ʒij.
Aquæ Rosæ *ad* ʒviij. M.

Use—Mild alkaline and antiseptic gargle.

51. ℞ Alum. Exsicc. ʒj.
Aquæ Rosæ ʒviij. Solve.

Use—Astringent.

52. ℞ Liq. Hydrarg. Perchlorid. ʒiij.
Aquæ *ad* ʒviij. M.

Use—In syphilitic pharyngitis.

53. ℞ Glycer. Acid. Tannic. ʒvj.
Sp. Vini Rect. ʒij.
Aquæ *ad* ʒviij. M.

Use—Astringent.

54. ℞ Potassii Chloratis ʒiv.

Sig.—Dissolve in a pint of water and use as a gargle.

55. ℞ Boracis
Potass. Chloratis āā ʒij.
Potass. Carb. ʒiij.
Sodii Chloridi ʒj. M.

Sig.—ʒj. in ʒxij. of tepid water to be used as a gargle or spray three times daily (Dr. Newman).

VI. Lozenges.

Suitable for congested or "relaxed" states of the throat.

These should be dissolved slowly in the mouth, and no liquid swallowed for a short time afterwards.

56. ℞ Troch. Krameriæ ʒj.

Sig.—One every four hours.
Use—A good astringent.

57. ℞ Troch. Cubebæ ʒj.

Use—Especially beneficial when there is excessive secretion from pharynx.

58. ℞ Troch. Guaiaci ʒj.

Sig.—One every two hours.
Use—In acute inflammation of tonsils.

59. ℞ Pastilli Menthol. (¼ gr. in each).

60. ℞ Pastilli Cocainæ Hydrochloratis ($\frac{1}{10}$ gr. in each, or more if required).

61. Compressed tablets, prepared by Wyeth or Burroughs, Wellcome & Co., of Chlorate of Potassium, Borax, Chloride of Ammonium, etc., are sometimes to be preferred to gargles.

VII. Embrocations and Counter-Irritants.

62. ℞ Liquor. Carb. Deterg. ʒj.
Aquæ *ad* ʒvj. M.

Use—In chronic scaly eczema of auricle or external meatus. The parts affected should be sponged or painted every six hours.

63. ℞ Tinct. Iodi ʒiv.

Use—In the milder cases of mastoid periostitis, and in disease of the labyrinth it is useful when applied behind auricle; also in facial paralysis.

64. ℞ Liniment. Iodi ʒiv.

Use—Same as preceding Formula.

65. ℞ Emp. Cantharidis Liquid. (Smith's) ʒj.

Use—For painting over mastoid process to produce vesication. Especially useful in facial paralysis, in labyrinthine disease, in paralysis of auditory nerve, and in distressing forms of tinnitus aurium; may be also useful in otalgia.

66. ℞ Liquor. Plumbi Subacet. ʒj.
Glycerini Puri ʒij.
Aquæ *ad* ʒiv. M.

Use—In acute eczema or diffuse inflammation of auricle, the parts affected to be gently but frequently sponged; or pieces of soft cloth dipped in the lotion may be kept constantly in contact with the morbid surface.

67. ℞ Zinci Carb.
Pulv. Zinci Oxidi āā ʒij.
Acid. Nitric. Dil. ♏x.
Sp. Vini Rect. ʒij.
Aquæ *ad* ʒiv. M.

Use—In eczema of auricle, parts affected should be gently sponged two or three times a day.

68. ℞ Liniment. Saponis
,, Camphor. Co. āā ʒj. M.

Use—In tinnitus aurium this is sometimes beneficial when applied with friction to the neighbourhood of the ear.

69. ℞ Liniment. Belladon.
,, Opii āā ʒiv. M.

Use—A few drops placed on a pellet of cotton wool and laid in the outer orifice of the ear gives great relief in painful inflammatory affections of middle ear, or in simple otalgia.

70. ℞ Liniment. Chloroform.
,, Aconiti
,, Belladon.
,, Opii āā ʒiv.
,, Saponis ʒj. M.

Use—Applied to the neighbourhood of the ear, this liniment allays the pain which often extends along the temples and head in inflammatory affections of middle ear, as well as in otalgia.

71. ℞ Æther. Sulphuric.
Glycerini Puri āā ʒij. M.

Use—A plug of cotton soaked in this and inserted into meatus is said by Politzer to be useful in torpidity of the auditory nerve.

72. ℞ Tinct. Valerian. ʒij.
Æther. Sulphuric. ʒj.
Glycerini Puri ʒxij. M.

Use—For painting repeatedly the cartilaginous part of the external auditory canal in tinnitus aurium (Politzer).

73. ℞ Menthol. ʒij.
Chloroform. (Methyl.) ʒiv.
Ol. Olivæ *ad* ʒij. M.

Use—In similar cases to Formula 70.

74. ℞ Acidi Carbolici gr. v.
Spirit. Rectif. ʒij.
Glycerini ʒij.
Aquæ ʒiv. M.

Sig.—For painting external meatus in pruritus or scaly eczema.

75. Acidi Salicylici gr. x.
Spirit. Rectif. ʒiij.
Glycerini ʒj. M.

Sig.—Same as preceding Formula.

76. ℞ Linimenti Capsici (Martindale) ʒij.

Sig.—For application behind the auricle in tinnitus and labyrinthine disturbances.

VIII. Solutions employed as "Ear Drops." (see p. 251.)

77. ℞ Acidi Borici (vel Resorcin.) gr. x.
Spirit. Vini Rect. ʒiv.
Aquæ *ad* ʒj. M.

Use—In purulent inflammation of the middle ear; also for injecting into the attic.

78. ℞ Zinci Sulphatis gr. viij.
Acid. Carbolic. Cryst. gr. viij.
Glycerini Puri ʒj.
Aquæ *ad* ʒij. M.

Use—Astringent and antiseptic. For chronic purulent affections of the external meatus and middle ear.

79. ℞ Hydrarg. Perchlorid. gr. i.
Sp. Vini Rectif. ʒj. M.

Use—A few drops instilled into ear in syphilitic disease of the external auditory canal, or in fungi of the ear.

80. ℞ Sp. Vini Rect. ʒj.

Use—Excellent remedy in certain cases of purulent disease of the middle ear; especially suitable when granulations or small polypi have sprung up (see p. 251), and for roots of polypi (see p. 265); also used for fungi in the ear and for destroying larvæ in external meatus.

81. ℞ Acid. Carbolic. Cryst. gr. x.
Sp. Vini Rect.
Aquæ āā ʒj. M.

Use—Fifteen drops are instilled into the ear, after thorough cleansing and drying; in chronic purulent inflammation of middle ear.

82. ℞ Iodoformi ʒss.
Sp. Vini Rect. ʒj. M.

Use—In chronic purulent inflammation of middle ear (see p. 252).

83. ℞ Acid. Salicylic. gr. ij—x.
Sp. Vini Rect. ʒj. M.

Use—In chronic purulent inflammation of middle ear. It may prove irritating in the larger proportions.

84. ℞ Sodii Bicarb. gr. x.
Glycerini Puri ʒj.
Aquæ *ad* ʒiv. M.

Use—For softening ceruminous collections prior to syringing (see p. 166).

85. ℞ Liquor. Morphinæ Hydrochlor. ʒiv.

Use—For painful inflammations of external meatus or middle ear. Ten drops to be warmed and instilled into the ear every two or three hours.

Instead of sedative solutions Gruber uses medicated gelatine preparations introduced with forceps. These may contain ¼ of a grain of liquid extract of opium, or ¹⁄₁₂ of a grain of hydrochlorate of morphia.

86. ℞ Argent. Nitrat. gr. xl.
Aquæ ʒj. Solve.

Use—As an application to the outer orifice of the ear in chronic scaly eczema; also for painting over the walls of the external canal when the cutaneous lining is thickened. In chronic suppuration of the middle ear (see p. 253). To nasal mucous membrane (see p. 132).

87. ℞ Acidi Carbolici gr. v.
Glycerini ʒj. Solve.

Use—A few drops to be instilled into the ear when there is great pain from purulent inflammation of middle ear (Hewetson).

88. ℞ Acidi Carbolici
Cocainæ Hydrochlor. āā gr. v.
Glycerini Puri ʒj. M.

Use—Same as preceding Formula (M'Bride).

89. Sodii Bicarb.
Acidi Carbolici āā gr. vi.
Glycerini ʒij.
Aquæ ʒij. M.

Use—For softening desquamative and cholesteatomatous masses in inner end of external meatus.

90. Peroxide of Hydrogen (10 vols. strength).

Use—For instilling into the ear or injecting into the attic (see p. 283).

IX. Solutions for applying to Middle Ear through Eustachian tube.

(For mode of application see pp. 71, 339, 366.)

91. ℞ Ammonii Chlorid. gr. v.
Aquæ ʒj. Solve.

92. ℞ Sodii Bicarb. gr. x.
Aquæ ʒj. Solve.

93. Pilocarpinæ Nitratis gr. ij.
Aquæ ℥ij. Solve.

Use—Supposed to assist the absorption of syphilitic products in interior of the labyrinth.

94. ℞ Potassii Iodidi gr. v.
Aquæ ℥j. Solve.

95. ℞ Ol. Vaselini ℥j.

Use—First suggested by Delstanche in cases of adhesions in the tympanic cavity.

X. Solutions suitable for syringing the Ear. (For method of syringing see pp. 67, 159.)

96. ℞ Acidi Boric. Calend. ℥iv.

Sig.—Twenty-five grs. to be dissolved in two ounces of hot water (see p. 390).

97. ℞ Resorcin. ℥iv.

Sig.—Same as above.

98. ℞ Glycerini Acidi Carbolici ℥ij.

Sig.—One drachm to be added to two ounces of hot water.

99. ℞ Liq. Potass. Permanganatis ℥ij.

Sig.—Forty minims to be added to four ounces of hot water.

100. ℞ Acidi Salicylici ℥jss.
Spirit. Rectif. ℥ij. M.

Sig.—A teaspoonful to be added to two ounces of hot water.

101. ℞ Hydrarg. Perchlor. gr. v.
Spirit. Rectif. ℥ij. Solve.

Sig.—A teaspoonful in two ounces of hot water.

XI. Solutions suitable for syringing the Nose.

102. ℞ Sodii Chloridi
,, Bicarb.
,, Biboratis āā ℥j. M.

A drachm to a pint of tepid water is a fair strength for syringing the nasal passages (see p. 128), but for different persons this may require to be modified.

103. ℞ Sodii Chloridi
,, Bicarb.
Ammonii Chloridi āā ℥j. M.

Use—As above.

104. ℞ Potassii Chloratis
Potassii Bicarb. āā ℥j. M.

Use—As above.

The medicaments included in these three Formulæ, as well as others, are prepared in the form of tabloids by Burroughs, Wellcome & Co., for convenience of patients when travelling.

105. ℞ Liq. Potass. Permanganatis ℥ij.

Use—Two drachms to a pint of tepid water. Especially suitable in ozæna.

106. ℞ Acidi Borici ℥ij.

Use—Two drachms to a pint of tepid water in ozæna.

107. ℞ Aluminii Aceto-tartaratis ℥iv.
Aquæ ℥j. Solve.

Use—One drachm to be mixed with a pint of tepid water for ozæna.

108. ℞ Glycerini Boracis ℥ij.
,, Acidi Carbolici ℥ij. M.

Use—Two drachms to be added to a pint of tepid water in ozæna.

109. ℞ Acidi Salicylici ℥iv.
Boracis ℥ij. M.

Use—One drachm to be added to a pint of tepid water in ozæna.

See the Formulæ under the heading of Spray Inhalations, which may be applied with a brush or cotton on a cotton holder to the nasal mucous membrane.

XII. Caustics.

110. ℞ Acid. Chromic.
Aquæ āā ℥j. M.

Use—For destroying roots of small aural polypi or hypertrophied mucous membrane; also in chronic rhinitis with hypertrophied spongy bodies; or to the roots of nasal polypi.

(For precautions see p. 133.)

111. Argenti Nitras.

A probe made of aluminium is made red hot at the point and pressed on to the salt, so that a coating of the fused salt will remain attached.

Use—Same as preceding Formula.

B.—GENERAL REMEDIES.

I. Remedies employed chiefly when the Ear Affection is associated with Anæmia or Tubercular Disease.

112. Bi-palatinoids of Bland's Pill (Ferrous Carbonate).

113. ℞ Mist. Ferri Co. ℥x.

Sig.—A dessertspoonful thrice daily.

Use—This is the old "Griffith's Mixture." A very useful and easily assimilated preparation of iron.

114. ℞ Ferri et Ammon. Citrat. ℈ij.
Liquor. Sodii Arseniatis ℥j.
Glycerini Puri ℥j.
Aquæ *ad* ℥iv. M.

Sig.—Two teaspoonfuls in water twice daily after food.

Use—In chronic eczema of auricle or external auditory canal; in recurrent furunculi in external auditory canal; also advocated by some writers as a useful remedy in tinnitus.

115. ℞ Vini Ferri Citratis ℥iv.

Sig.—One to four teaspoonfuls twice a day after meals.

116. ℞ Ext. Aloes
Ferri Sulphatis
Pulv. Zingib. āā gr. i.
Ext. Gentian. q.s. M. Fiat pilula.

Sig.—One thrice daily.

117. ℞ Tinct. Ferri Perchlorid. ℥ij.
Liq. Strychninæ Hydroch. ♏xlviij.
Aquæ *ad* ℥vj. M.

Sig.—A tablespoonful in water thrice daily after food.

118. ℞ Syrup. Ferri Iodid. ℥iv.
Glycerini Puri ℥jss.
Aquæ *ad* ℥iv. M.

Sig.—One or two teaspoonfuls thrice daily.

119. ℞ Syrup. Hypophosphit. Co. (Fellows') } ℥vj.

Sig.—For an adult, a teaspoonful three times a day after food.

120. ℞ Syrup. Phosphat. Co. (Squire) ℥iv.

Sig.—Thirty to sixty minims in water thrice daily.

121. ℞ Potassii Iodid. gr. viij.
Ferri et Ammon. Citrat. gr. xxiv.
Syrup. Simp. ℥j.
Aquæ *ad* ℥iv. M.

Sig.—For children, one or two teaspoonfuls thrice daily.

122. ℞ Calcii Sulphid. gr. ¼. Fiat pilula.

Sig.—One every four hours.

Use—Said to limit or cut short boils in the external auditory canal.

II. Remedies employed chiefly where Syphilis complicates an Ear Affection.

123. R Hydrarg. Perchlorid. gr. i.
Potassii Iodid. ℥ij.
Tinct. Calumbæ ℥ij.
Aquæ *ad* ℥vj. M.

Sig.—Two teaspoonfuls in a glass of water three times a day.

124. R Hydrarg. Perchloridi gr. i.
Tinct. Cinchon. Rub. ℥iij. Solve.

Sig.—A teaspoonful in water thrice daily.

125. ℞ Potassii Iodid. ℥ij.—℥vi.
Ammon. Carb. ℥j.
Syrup. Aurant. ℥vj
Infus. Calumbæ *ad* ℥vj. M.

Sig.—A tablespoonful in water thrice daily.

Use—Recommended in smaller doses by Politzer for relieving the pain of caries; also recommended in facial paralysis. In larger doses, used in syphilitic disease of labyrinth.

126. R Potassii Iodid. ℥j.
Ferri et Ammon. Citrat. ℥ij.
Infus. Calumbæ *ad* ℥vj. M.

Sig.—A tablespoonful in water thrice daily.

127. R Sol. Pilocarpin. Nitrat. (2 per cent.) } ℥j.

Sig.—Four to ten minims for each injection, used hypodermically.

Use—In syphilitic disease of labyrinth; also in Ménière's disease.

Messrs. Burroughs, Wellcome & Co.'s tabloids of Pilocarpine are very convenient, beginning with $\frac{1}{12}$ of a grain and going on to ¼ or ⅓.

III. Aperients, Antacids, and Tonics, when the Ear Affection is associated with Dyspeptic, Rheumatic, Gouty, or Lithæmic conditions.

128. ℞ Hydrarg. c. Cretâ gr. i.
Sodii Bicarb. gr. ij.
Pulv. Rhei Opt. gr. iij. M. Fiat pulvis.

Use—Suitable aperient and antacid for a child. Larger doses according to age.

129. ℞ Bismuth. Carb. ℥jss.
Potassii Bicarb. ℥ij.
Inf. Calumbæ *ad* ℥vj. M.

Sig.—A tablespoonful in a glass of water thrice daily.

130. ℞ Magnes. Carb. Pond. ℥jss.
Magnesii Sulphatis ℥iv.
Tinct. Cardam. Co. ℥iij.
Tinct. Zingib. ℥iij.
Aquæ Menthæ Pip. *ad* ℥vj. M.

Sig.—A tablespoonful in a glass of water twice daily.

131. ℞ Ferri et Quin. Citr. ℥ij.
Lithii Citratis ℥iss.
Tinct. Aurantii ℥vj.
Aquæ *ad* ℥vj. M.

Sig.—A dessertspoonful in water twice a day after food.

132 (*a*). Carlsbad Salt (in fine powder).

Sig.—A teaspoonful in a large tumblerful of hot water sipped half an hour before breakfast.

132 (*b*). Hunyadi János, Püllna, or Friedrichshall Bitter Water.

Sig.—Half a tumblerful filled up with hot water in the early morning.

Use—Frequently beneficial in allaying subjective sounds in the ear.

133. ℞ Pilulæ Hydrargyri
Pilulæ Rhei Comp.
Extracti Hyoscyami āā gr. xx. M.
Divide in pilulas xij.

Sig.—Two to be taken occasionally at bedtime.

134. ℞ Liquor. Strychninæ Hydrochloratis ℥jss.
Acid. Nitro-Mur. dil. ℥ijss.
Succi Taraxaci ℥jss.
Sp. Chlorof. ℥jss.
Aquæ *ad* ℥vj. M.

Sig.—Two teaspoonfuls in water three times a day after food.

135. ℞ Sp. Chloroformi ℥ij.
Tinct. Quininæ Ammon. *ad* ℥ij. M.

Sig.—A teaspoonful in a wine-glassful of water every three or four hours. The first dose to be double that quantity.

Use—Recommended by Hovell for "cold in the head."

IV. Diaphoretics, Sedatives, Febrifuges.

136. ℞ Pulv. Ipecac. Co. gr. xij.

Full dose for an adult.

Use—In acute naso-pharyngeal catarrh, it may shorten the attack; sometimes required for the relief of painful inflammatory affections of the ear.

137. ℞ Phenacetin. gr. x.
Exalgin. gr. ij. M.

Use—For relief of pain and feverishness in acute stage of purulent inflammation of middle ear.

Phenacetine may also be employed in the form of compressed tabloids (5 grs. in each).

138. ℞ Antipyrin. Cryst. gr. xv.

Use—Same as above. Frequency of dose to be regulated by prescriber.

139. Sulphonal. gr. xxv.

Sig.—To be taken suspended in water for causing sleep, which may not follow for an hour after.

140. ℞ Inject. Morphinæ Hypodermic. P. B. ℥ij.

Sig.—One to six minims to be subcutaneously injected.

Use—Sometimes called for in very painful inflammatory affections of the ear; may be required for the relief of intense otalgia.

V. Special Remedies chiefly employed for the relief of subjective sounds in the Ear.

141. ℞ Acid. Hydrobromic. Dil. ℥i.
Aquæ *ad* ℥iv. M.

Sig.—Two teaspoonfuls in a tablespoonful of water three times a day.

Use—In certain forms of tinnitus aurium; also in auditory vertigo this remedy has a beneficial effect.

142. ℞ Potassii Bromid. gr. xx.—℥j.

Sig.—Dissolve in a large quantity of water and take at night.

Use—Should be employed if cerebral symptoms or vertigo arise in connection with ear disease; also in severe forms of tinnitus, especially when associated with nervous excitement; drachm doses at bed-time may give great relief.

Bromide of Sodium is said to be less depressing—the dose should be the same as Bromide of Potassium.

143. ℞ Ammonii Bromidi ℥ijss.
Aquæ *ad* ℥ij. Solve.

Sig.—A teaspoonful in half a wineglassful of water two or three times a day.

144. ℞ Sodii Salicylatis ℥iv.
Aquæ ℥ij. Solve.

Sig.—A teaspoonful in water twice or thrice daily.

145. ℞ Infus. Digitalis ℥iv.

Sig.—Two teaspoonfuls twice daily.

Use—In pulsating forms of tinnitus aurium.

146. ℞ Quininæ Sulph. gr. xij.—℥j.
Syr. Aurant. ℥vj.
Aquæ *ad* ℥vj. M.

Sig.—A tablespoonful for a dose after shaking up the mixture.

Use—In smaller doses every three or four hours, given in simple otalgia; the larger doses to be given every two or three hours in phlebitis, thrombosis, or pyæmia: also in Ménière's disease after the first few weeks.

147. ℞ Zinci Valerian. gr. ij.
Ext. Nucis Vomic. gr. ¼.
Ext. Gentian. gr. ij. M.
Fiat. pilula.

Sig.—One three times daily.

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